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THE LAUNCH OF H. M. S. "ALBION."

ON Tuesday, June 21, H. M. S. "Albion" was launched at the shipyard of the Thames Ironworks and Shipbuilding Company at Blackwall, the christening ceremony having been performed by the Duchess of York. Of the vast crowd that gathered and cheered themselves hoarse and sang with all their British might, "God Save the Queen," as the great battleship glided into the water, few, if any, knew at the time of the terrible disaster which marred the day's proceedings, of the many human lives which had been lost. As the Duchess of York cut the slender cord which ostensibly held the "Albion" to her slip, who could divine that the battleship would carry such destruction with her? Not until long after the "Albion" had been launched did the English people learn of the catastrophe which turned their rejoicing into deep mourning.

The launch in itself went off smoothly enough, the ship taking the water without the slightest difficulty; but the backwash caused by the displacement of water as the vessel was launched carried away a bridge used as a gangway by workmen and with it the crowd which stood upon it. This bridge constituted the continuation of a stone quay erected partly over the foreshore and partly over the water. Notice of warning had been placed at the gangway, but the small police force present was unable to keep back the obstinate and willful East End crowd. As the "Albion" took the water, a great boiling wave rolled back, swept up beneath the wooden floor, lifted it bodily from its fastenings and, retreating, carried with it out into the basin, the two hundred human beings stationed upon the gangway. The wrecked staging itself was responsible for many of the deaths that occurred. Boats and rescue parties immediately put out and many gallant deeds, it is said, were performed. That royal sympathy was not wanting for those who perished, goes without saying. Telegrams of anxious inquiry were sent by the Duke and Duchess of York, and expressions of sorrow and sympathy were conveyed to the relatives of those who had been lost.

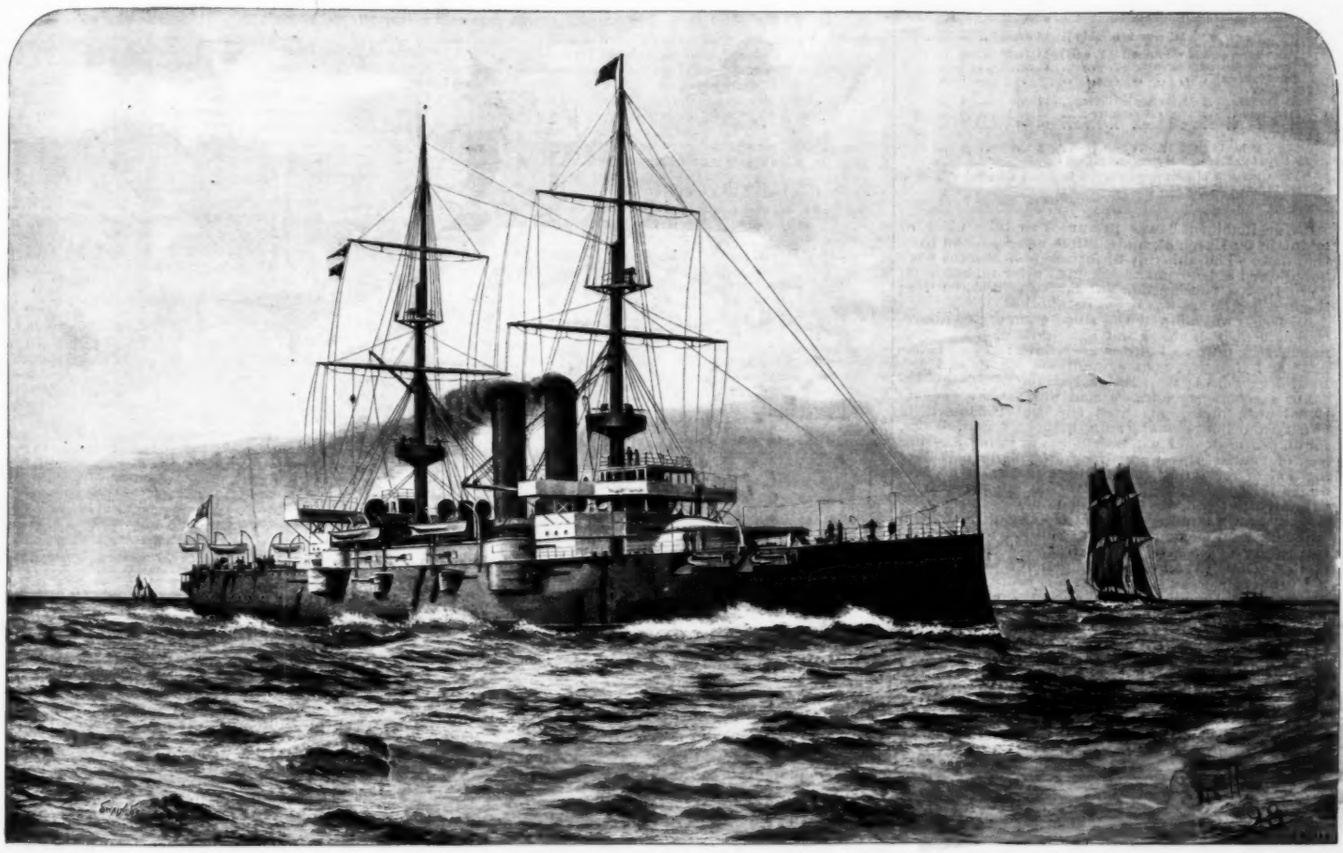
The cause of this terrible catastrophe, H. M. S. "Albion," is destined to become one of England's finest battleships. According to The Engineer, to which we are indebted for our engraving, the "Albion" is 390 feet in length between perpendiculars, has an extreme breadth of 74 feet, and displaces 13,000 tons at the load water line, at which her draught, both forward and aft, is 26 feet. She is built throughout of steel, and is protected on her sides by a belt of 6-inch Harveyized steel, 195 feet in length, extending 5 feet below the water line and 9 feet above it. At the end of the belt curved bulkheads of the same material, 12 inches, 10 inches, and 8 inches in thickness cross the ship and meet the sides of the two barbettes. Both barbettes are circular, are protected by 12 inches of armor on the upper tier of plates and by 6 inches on the lower tier, the latter being the side armor. Two conning towers, the forward one protected by 12 inches of Harveyized steel and the after one by 3 inches of nickel steel, are located as shown in the engraving, the former being in front of the foremast and the latter just abaft the mainmast.

Outside the hull plating, from the forward bulkhead to the stem, and running down to the keel in the wake of the anchor chafe forward and from the after bulkhead to the stern down to the same, nickel steel plates, 2 inches in thickness, are worked and thus practically form the continuation of the belt. The decks of the "Albion" include an armored protective steel deck 2 inches thick extending from stem to stern, and rising from the lower edge of the side armor belts to 2 feet 6 inches above the loadline amidships, curving down at both ends of the ship; and main and middle decks, which, between the armored cross-bulkheads, are protected with steel plates ½ inch and 1 inch thick respectively.

The ship's armament consists of four 12-inch 46-ton breech-loading wire guns on turntables, two in each circular barbette, with all-round loading mountings, the guns being protected by Harvey steel shields 8 inches thick; twelve 6-inch rapid-fire guns, eight on the main deck, and four on the upper deck in casemates; ten 12-pounders, six on the upper deck amidships and four on the main deck forward and aft; six 3-pounder Hotchkiss guns, three in the military tops of each mast; two 12-pounder boat and field guns, eight 0·45-inch Maxims and six Howitzers. The casemates for the 6-inch rapid-fire guns are protected by 6-inch armor and back plates 2 inches thick. The forward and after guns in the end main deck casemates can be fired right forward and aft respectively, and train through an arc of 120 degrees. The ship will carry fourteen 8-inch and five 14-inch torpedoes, the latter fired with dropping gear from the ship's pinnaces.

The ram bow, it will be observed, is much higher than in former English battleships, the ram point being only from 7 feet to 8 feet below the surface of the water, while the forefoot rises at an abrupt angle from the keel, instead of being curved. The point of the ram is well supported by the stem, by the armored deck and inside stiffness, as well as by the shell plates and nickel armor, rendering the whole a solid yet cellular mass and at the same time stiff and elastic.

The "Albion's" machinery will be supplied by Maudslay Sons & Field, Ltd., and will consist of two independent sets of three-cylinder inverted triple expansion engines, to develop 13,500 indicated horse power, each set driving a screw 17 feet in diameter, fitted with adjustable blades, the ship being designed to run 18½ knots an hour. Steam will be supplied by twenty Belleville water-tube boilers to be placed in three water tight compartments. The total coal-carrying capacity of the ship is 1,900 tons, 930 being stowed in the lower bunkers, 390 in the wings next to the ship's skin, and 580 tons on the protective or middle deck at the sides of the ship, sufficient to enable her to steam for about 30 days at a 10-knot speed, with due allowance for auxiliary purposes. The hull of the "Albion" is constructed on the bracket system, all work therein up to the height of the upper deck being made watertight.



HER MAJESTY'S FIRST-CLASS BATTLESHIP "ALBION."

The largest cargo ever carried on the great lakes was loaded into the "Superior City," at Counselman's elevator, in South Chicago, recently. It consisted of 266,550 bushels of corn, weighing 7,462·9 net tons, put on board in seven hours. It is said that this eclipses all previous loading records. The mean draught of the vessel, with a large amount of fuel on board, was 18 feet 2 inches. The vessel arrived at South Chicago from Escanaba with a cargo of 6,754 gross tons of iron ore. This was discharged at the Illinois Steel Company's dock in exactly 12 hours, by 143 men, which is said to be the most rapid work of the kind on record.

THE NAVAL WAR GAME—A STRATEGICAL CAMPAIGN.

THE experiments with the Naval War Game have lately taken a strategical turn, or rather have combined a strategical with the tactical game. It was at first intended to play out a war between Japan and Russia, but a sufficient number of players for all the ships not being forthcoming at the time, a simpler war was resolved upon, the British Isles being split up in maneuver fashion, with the important difference that trade was allowed for, and coal endurances much reduced. The post of Blue "Admiralty" was taken by Lieutenant R. Kawashima, of the Imperial Japanese Navy, who was to have controlled the Japanese operations in the projected "Russo-Japanese War"; the Red movements were directed by Mr. Fred T. Jane, the inventor of the game.

The accompanying sketch map illustrates the territory assigned to either side. Each of the towns marked was valued at 50 points except Glasgow and Edinburgh, which were 150 each; Hull and Sligo, which were each 100. The bases—Queenstown, Devonport, and Milford for the Blue; Portsmouth and Sheerness for the Red—were considered impregnable from the sea, but could be taken by land. The rival fleets were as follows:

Blue.

		Speed allowed.	Coal allowance for
At Devonport—			
Cristobal Colon.. Garibaldi	Armoured cruiser ..	18 knots ..	7 days.
Brandenburg .. Boxer .. .. .. Bruiser..	1st class battleship .. Destroyer	15 " .. 24 " ..	4 " 2 "
Earnest	"	27 " ..	2 "
Torpedo boat, 60 class ..	T.B.	18 " ..	1 "
*Two liners (armed)..		15 " ..	6 "
One collier..		9 " ..	7 "
At Milford—			
Growlatchy ..	Armoured gunboat ..	9 " ..	2 "
Thunderer	2nd class battleship ..	12 " ..	4 "
Apollo	2nd class cruiser ..	18 " ..	5 "
At Queenstown—			
Ten merchantmen		9 " ..	4 "

Red.

		Speed allowed.	Coal allowance for
At Portsmouth—			
Indiana .. .. Massachusetts ..	1st class battleship ..	15 knots ..	5 days.
*Three liners (armed with small Q.F. only)		15 " ..	6 "
Three '30 class torpedo boats		21 " ..	1 "
Three colliers		9 " ..	7 "
At Chatham—			
Alexandra	2nd class battleship..	12 " ..	4 "
Hermione	2nd class cruiser ..	18 " ..	8 "
Seagull	Catcher..	18 " ..	3 "
At Hull—			
Ten merchantmen		9 " ..	4 "

All ships had their actual guns and armour.

* The armament of liners was allowed to either side, but only Blue elected to arm with 6in. or 4·7in. guns.

"War imminent" was presumed to take place at midnight on March 31, and all time was reckoned from that date. The ships at Sheerness and Milford were not allowed able to put to sea until after midnight on April 1. No "declaration of war" was allowed for; the first hostile act was to constitute that.

Each side was allowed the ships enumerated above, complete with all stores and ammunition, the impregnable bases, and coal stores as follows: Blue, Liverpool and Glasgow, each enough for ten days, Holyhead fifteen days; Red, Hull fifteen days.

For convenience a day's coal was made a conventional unit, and represented the coal consumed in twenty-four hours by any ship, without regard to size, for all purposes, and whether at sea or in harbor—unless, of course, fires were drawn. A more elaborate method of reckoning exists, but as it serves no adequate purpose in comparison to the labor involved, this universal unit was substituted.

Each side was allowed 20,000 troops, disposable at will, any land encounters being subject to numerical superiority only, save that entrenched troops count double. To defeat an enemy completely a proportion of two to one is necessary; with a smaller proportion, losses are on a corresponding scale. Each liner was allowed to embark 1,000 troops, each merchantman 500, and these were assumed to be in the proper proportion of all arms. Military operations, in fine, have been treated as naval ones are in the strategical army game—that is, sufficiently allowed for, for the necessary approximation, and nothing more.

In addition, 2,000 points were assigned to each side, and from these points all coal, repairs, fortifications, and ammunition had to come. They were to be increased only by exacting ransoms or by trade—each merchantman could embark ten points, which, after its return to the starting port, became trebled. On the other hand, the loss of points due to a bombardment had to be paid for out of the general total.

Costs were arranged generally as follows:

Every day's coal for one ship	1 point.
Every round of ammunition	1 "
Mines sufficient to cover 100 yards	3 "
Guns of 12in. or over	50 "
Guns of 11in. or 10in.	40 "
9in. or 8in. quick-firing	30 "
6in. quick-firing	20 "
4·7in. quick-firing	10 "
Battery of Hotchkiss	10 "
Every 8ft. of fortification	1 "
Every 8ft. of ship repaired	1 "
To coal, take in ammunition, embark or disembark troops, or get ransom from a town	12 hours.
To capture a merchantman	6 "
To bombard an unfortified town of 50 points	3 "
" " " 100 "	4 "
" " " 150 "	6 "

It was necessary to fire twenty-five rounds for every 50 points of town destroyed. Further, the ammunition supply of ships was kept at a low figure; sufficient for one action only in most cases—about fifteen "rounds" per gun on the average, or fifteen minutes' rapid fire from a quick-firing gun.

The usual laws as to neutral ports and waters are enforced in the strategical game. Other rules bearing upon the "war" under review are as follows:

Each Admiralty may communicate with its ships at sea only by coastguard or dispatch vessel, or by telegrams sent to and received in a neutral harbor. Weather was allowed for on a scale known to none of the players for more than twenty-four hours ahead, the usual 0 to 9 force of wind notation being allowed, and speeds and maneuvering qualities were subject to the state of the sea. Tides were conventionally assumed as 3 knots in all cases, and for all harbors and shallow waters Admiralty charts were to be employed.

All actions were to be fought out by the usual tactical rules of the game; the interim period, between when ships sighted one another and came within firing range, being played in ten moves on squares of the assumed size of 1,000 yards each. There was, consequently, ample scope for seeking to select the most favorable position for going into action, and in one fight this preliminary stage produced some exceedingly interesting evolutions, which will be referred to later in their proper place.

All courses were marked upon charts, generally in six-hour runs; whether or no, ships sighted or met each other was, therefore, easily calculated by the umpire. On the umpire's map every move of both sides was charted; each Admiralty charted only its own moves, and what had been discovered or reported of hostile ones; there was, consequently, a good deal of "moving in the dark."

An inspection of the map and the hostile fleets will show that the forces were relatively about equal, since Blue's trade was more easily to be attacked, and in the paucity of points upon either side, trade was of vital importance. The necessity of protecting three different bases with troops rendered Blue's position more easily menaced by Red troops, especially as Red had more transports, though Blue left Ireland, Wales and Scotland to the mobile defense, and concentrated nearly all his army in and about Devonport. On the other hand, at "war imminent" Red had no ship of over 15 knots; every town on the coast risked, therefore, being at the mercy of the "Cristobal Colon" and "Garibaldi." On the assumption that Blue would avoid a fleet action and attempt this *guerre de course* directly the hour for leaving was passed, Red sent the "Massachusetts" on guard duty toward Dover in touch of the coast, while with the coastguard, went away south, one hunting for Blue merchantmen, the other intent on cutting the Brest cable. They remained off Brest some hours without result. In the meantime the "Massachusetts" was hastily recalled, and, picking up two torpedo boats at Portsmouth, made for Exmouth.

This place was reached at midnight, April 1-2, and immediately bombarded, possibly in the hope of forcing an action with the two armored cruisers; but these ships had left Devonport immediately after getting the prize in the sound, and cruising toward their trade route fell in with and captured one of the Red liners, while the other escaped into the neutral harbor. The captured vessel was sent back to Devonport with a prize crew, off which place she fell in with the Red torpedo boats, which effected a recapture. She was sent back to Portsmouth, while the Red squadron went west looking for the cruisers, which they failed to find, and awaiting the Sheerness squadron, which was now coming down the channel at full speed. The Blue cruisers had gone round the Land's End, and having been joined by the "Thunderer" and "Apollo," cruised along off the Lizard, trying to find the "Massachusetts." Taught by the fate of the "Indiana," this ship made off when sighted, and after a long stern chase was overhauled by the 18-knot ships, the "Thunderer" by then being out of sight astern.

Suddenly putting down helm, the "Massachusetts" turned toward the chasers, which were then in line ahead on the starboard quarter, the armored vessels leading, the "Apollo" quite 3,000 yards astern of them, watching the Red torpedo boats.

The "Colon" and "Garibaldi" turned eight points to port, bent on attacking the unarmored ends, as they had done off Portland. By turning thus they saved the "Apollo" from being cut off, but the "Massachusetts," passing between them at well under 2,000 yards, was able to engage them on either broadside. She quickly got an armor-piercing shell into the "Colon's" engines and nearly silenced the "Garibaldi"

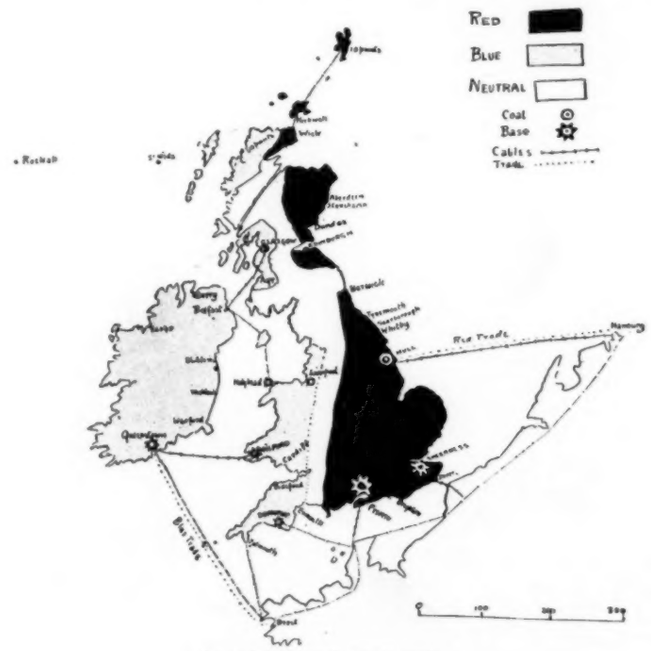


Fig. 1—NAVAL WAR GAME MAP

the "Indiana," accompanied by two liners, armed with light quick-firers only, as scouts, made toward Exmouth with the intention of shelling that place, in order to distract Blue's attention from the anticipated attack on towns.

It so happened, however, that the Blue fleet sailed with the order, "Find the enemy, engage him, and obtain command of the sea." This fleet consisted of the "Cristobal Colon" (flag), "Garibaldi," "Brandenburg" and three destroyers. Proceeding due west, the "Cristobal Colon" and one of the Red transports presently sighted each other. The "Cristobal Colon," sighting the "Indiana" also, turned and went east again, while the destroyers, which had been on her inshore side, hurried back to inform the other ships. When the "Indiana" came in range of them, with the liners about three miles off on either beam, the enemy were in line ahead at two cables, three warships and three destroyers. Before this force she should certainly have turned and made back to Portsmouth, or at the most made a running stern fight.

The "Indiana's" player, however, did neither the one nor the other, but went straight for the Blue ships, which continue their course, firing heavily at his unarmored parts. These they soon destroyed and reduced the ship's flotation and speed. The funnels were brought down, the fore turret jammed, the 8-inch turrets silenced, all in a very short while. The Blue ships, by standing off, might have completed their work of destruction, but fearing the big guns, they stood in to ram.

The "Indiana," unable to steer save a very wide circle, and with hardly any speed, was an easy target. A torpedo disposed of the "Brandenburg," but a moment later the ship struck to the "Cristobal Colon," which turned aside only just in time to avoid ramming her prize. The two cruisers, taking the prize and the water-logged "Brandenburg" in tow, went back to Devonport, being joined by two of the destroyers. The third, the "Bruiser," had, it transpired, been sunk by one of the liners, near which she had incautiously ventured.

The liners after the action, having communicated guns. The end attack was sufficiently successful, however, to reduce the "Massachusetts'" speed considerably, so that the "Garibaldi" had gone on a considerable way ere the Red ironclad turned. When she did, a great deal of fire was wasted in a vain attempt to hit the little "Apollo," which bore down to the disabled "Colon" and took her in tow without sustaining the slightest injury. More, she opened fire with her 6-inch and 4·7-inch quick-firers, and, firing high explosives, blew away the sighting hood of the "Massachusetts'" fore barbette just as it was about to fire at 1,500 yards. In the delay thus caused she got the "Colon" between her and the enemy, and towed some considerable distance, increasing the range every move, with the tide in her favor, while the "Massachusetts" was endeavoring to turn. At 3,000 yards, however, a 13-inch high explosive shell hit the "Apollo" on the water-line, sinking her. Out of a total of forty shots fired, this was the sole hit. The "Colon" now struck. The "Garibaldi" had some time since disappeared, having made away home without awaiting results. It appeared later that this ship had had every gun disabled, lost 75 per cent. of her fighting crew—including those sent away in the transport that had been captured—and been penetrated rather badly on the belt. The engines were, however, intact, and the Red ship quite ignorant of the damage inflicted, and, had she tried to ram, it is quite possible that the "Massachusetts" would have been captured.

Ere the "Massachusetts" could take possession of the "Colon," the "Thunderer" came up. At 4,000 yards a 13-inch common shell blew away the greater part of the superstructure, reducing speed considerably. She had, however, enough remaining to be able to escape from the "Massachusetts," and was soon out of range. The Red torpedo boats were therefore ordered to attack. They advanced under a feeble fire that did no execution. The first boat missed with both torpedoes, but the other secured a hit. The "Thunderer," water-logged and helpless, refused to strike to a torpedo boat; one boat therefore went back for the Red ironclad. The "Thunderer" suddenly opened fire on the other and sank her. After dark

the "Massachusetts," towing the "Colon," came up, and the "Thunderer" struck. She, too, was taken in tow, and the tide having turned, the battered flotilla made toward the rendezvous where the "Hermione" was expected, moving little swifter than the tide.

They had hardly started when a destroyer was sighted. The prize crew in the "Colon" manned the quick-firing guns, and search-lights were burnt. The boat, the "Earnest," was sunk; but a second destroyer, the "Boxer," came along unhurt. The Red torpedo boat made a brilliant but utterly futile attempt to ram, and by mistake got fired at, though not hit, by the prize crew in the "Colon." The "Boxer," unattacked, headed straight for the "Massachusetts," which had not a single quick-firer left, and discharged a torpedo at 200 yards, which missed, although it was given a 5 in 6 chance; and the destroyer passed on at full speed, was seen nothing more of; so the squadron proceeded. The "Thunderer" claimed to have killed off the prize crew and recaptured the ship during the excitement of the torpedo attack; but this was disallowed.

The "Hermione," having been picked up in company with the liner that had escaped into Brest—and left, as it subsequently turned out, only two or three hours before a Blue merchant fleet came in—stood in toward Portland. Here the "Hermione" received urgent orders to proceed to the East Coast, Brighton and Dover having been bombarded by two Blue liners that had since gone into the German Ocean, presumably to attack the trade route. The rest of the ships, after weathering a dangerous squall—dangerous, that is, to the extent that both the "Massachusetts" and the "Thunderer" had to take even chances of foundering—reached Portsmouth and were docked. An arbitrary limit of seven days only was given for repairs to be effected—a period that, in the case of a ship like the "Massachusetts," not injured by torpedo or in the engines, might be reduced by foregoing the renovation of certain guns. The Blue ships "Garibaldi," "Brandenburg," and the captured "Indiana" had been given seven days in dock also. The active fleets were thus reduced to: Red—"Alexandra," "Seagull," two torpedo boats, and "Hermione;" while the Blue had nothing fit for sea except the "Grosiatschy," a torpedo boat, the "Boxer," and the two armed liners. These last the "Hermione" came up with off Whitby, having learned their whereabouts from the coastguard at Hull, off which place they had delayed to capture and sink two merchantmen. They were just bombarding Whitby when the "Hermione" came up. Each was armed with a 6-inch quick-firer in the bow and another in the stern, two 4·7-inch quick-firers on each broadside. The combined broadside was therefore four 6-inch and four 4·7-inch against the two 6-inch and four 4·7-inch of the "Hermione." They made enormous targets, and their engines were altogether exposed, but their enormous size made their destruction likely to be a work of considerable time, and both vessels made a running fight for it, taking a more or less end on position, which, as it compelled the "Hermione" to do the same, exposed her to a rake in the bow waterline, and a consequent loss of speed and inability to overtake.

The formation adopted was, on the whole, the best for the liners, and not until she had received considerable damage did the "Hermione" succeed in pitching a shell into the engines of one of the liners. She got this prize into Hull, when she herself had to undergo repairs to funnels and bow. The second liner escaped northward, and was not heard of again for several days. At the time Red calculated that, as she had neither coal sufficient to get round by Scotland further than the Hebrides, and next to no ammunition left, she would probably be a negligible quantity.

The "Alexandra" and the catcher "Seagull" having coaled from a collier at Portland, sailed with that collier and a liner carrying 800 men and stores for the Scillies, with orders to seize an island and establish a base for attacks on Blue trade, first bombarding Falmouth and destroying all shipping and docks there. No shipping was found, but the town and docks were destroyed, and having learned that not more than 2,000 troops were in the West of England—information that subsequently proved quite inaccurate—the captain of the "Alexandra," who was in command of the expedition, telegraphed via France for permission to make Falmouth a base. This was acceded to; 1,000 more troops were sent, as well as guns, stores, and ammunition. All available merchant ships were ordered round to Portsmouth. Fortifications were erected and mines laid down, the Red ships passing and repassing Devonport without hindrance, save that on the 6th of April a collier reported chase by the "Grosiatschy."

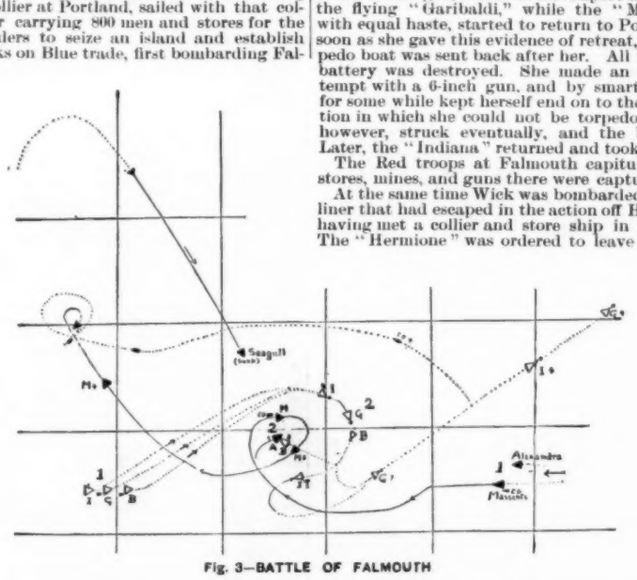


Fig. 3—BATTLE OF FALMOUTH

The "Massachusetts" was hastily ordered to sea, minus her 8-inch guns, acting as convoy to a liner-transport. The "Alexandra," disguised as a collier, went out to try and find the "Grosiatschy" on the 7th, but failing in this, went on to join the "Massachusetts."

At 6 A. M. on the eighth day 12,000 Blue troops attacked Falmouth, and a Blue fleet, consisting of the repaired "Brandenburg," "Garibaldi," the captured "Indiana," the "Boxer," and a torpedo boat—constituting the Southern squadron, with the "Brandenburg" as flag—left Devonport to reach Falmouth at noon to co-operate.

They fell in with the Red fleet—the "Alexandra," "Massachusetts," and one liner full of troops—proceeding leisurely toward Falmouth also, just as the "Seagull" and torpedo boat came up with news as to what was happening on shore.

Tactically, the battle that ensued was the most interesting ever fought. The odds were heavy against the Red, in appearance; but the large 10-inch battery of the "Alexandra" to some extent mitigated this, the big shell being a strong factor. The formations adopted are indicated by the plan. As regards details, the Red shooting was so successful that the greater part of the Blue heavy guns were silenced, every shot from the "Massachusetts" telling. The "Alexandra," devoting her main deck battery to the ends of the "Indiana," soon reduced the fighting and tactical value of that ship, while her upper deck battery so mauled the "Garibaldi" that that ship drew out of line and made off again, much as she had done in a previous battle. Victory seemed secured, when the "Alexandra," foolishly getting end on to the "Indiana," received two 13-inch solid shot that raked her low in the belt. Her boilers destroyed, she was at once charged by the "Brandenburg." The "Massachusetts" tried to ram this ship, but failed; the "Seagull" and torpedo boat delivered an attack, only to be sunk. The "Alexandra" raked the "Brandenburg," but not soon enough to stop her, and the two ships collided. Having no ability to withdraw, the Blue ship went down with the Red. About this time the "Boxer," which had kept under the lee of the "Indiana," was exposed, fired at, and sunk. Firing now became very slow, as on neither side were many guns available. The "Indiana" had only 8-inch guns left, the "Massachusetts" but one 13-inch—the sister gun in that (the fore) barbette having been hit by a 6-inch shot and broken—and two 6-inch guns. In this state of affairs the "Indiana," much submerged, made for Devonport in the wake of the flying "Garibaldi," while the "Massachusetts," with equal haste, started to return to Portsmouth. So soon as she gave this evidence of retreat, the Blue torpedo boat was sent back after her. All her Hotchkiss battery was destroyed. She made an ineffectual attempt with a 6-inch gun, and by smart maneuvering for some while kept herself end on to the boat—a position in which she could not be torpedoed. She was, however, struck eventually, and the boat escaped. Later, the "Indiana" returned and took possession.

The Red troops at Falmouth capitulated; all the stores, mines, and guns there were captured.

At the same time Wick was bombarded by the armed liner that had escaped in the action off Hull, this vessel having met a collier and store ship in the Hebrides. The "Hermione" was ordered to leave Hull and destroy her, and the vessel declared a pirate. Before anything could be done, however, an armistice was declared, Red suing for peace.

The command of the sea was definitely lost, and though the "Hermione" might have done considerable damage to Blue towns and shipping, her eventual capture was assured. Blue was able to blockade Portsmouth, and detach the "Garibaldi," so soon as repaired, to Hull, where all merchant ships would have been captured, and the other possible home port of the "Hermione" closed. Having command of the sea, Blue could easily have supplied his ships with coal, or landed troops and captured all Red bases in detail.

It is difficult to see what other end the war could have had, after Red's first mistake in allowing his "Indiana" and "Massachusetts" to be attacked in detail. The false move on Falmouth was a minor error strategically, assuming the information about the Blue force to have been correct. By Red's calculations the force at Falmouth could have held out unsupported for twenty days or more, and by them the command of the sea could have been secured and retained. It was bad in the sense that the "Alexandra's" captain never took the trouble to verify his information, which, by the rules, he could easily have done by the expenditure of a little time. It was bad also in that the Red fleet allowed the Blue to meet it before being reinforced by the "Thunderer" and captured "Colon," and a torpedo boat that for some reason remained entirely inactive at Sheerness, whither it had been sent on the outbreak of war. The Red plan of advance upon Devonport fell through also, owing to the inability to collect ships enough to land troops at Torbay to co-operate with those at Falmouth in the move against Devonport. The capitulation of the Falmouth force to Blue troops was a minor matter. The command of the sea lost, these would have been isolated and compelled to surrender, while any number of troops could have been brought over sea against them by Blue.

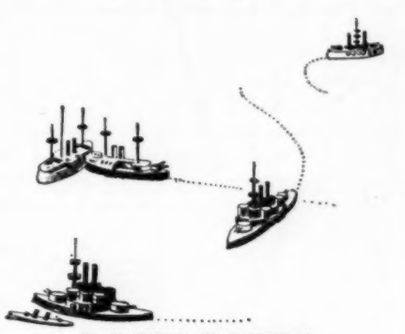


Fig. 2—BATTLE OF FALMOUTH

The rules worked well, and proved, so far as could be judged, to approximate fairly nearly to actual conditions, saving always that the arbitrary limit of time for repairs made things excessively rapid. As, however, the Red landing force had to lose no time for "preparations" before embarking, this arbitrary time limit cannot be said to have affected the issue to any important degree.

The main point brought forward is that an invasion is quite possible upon a temporary and also prospective command of the sea. Had Red secured this command, nothing would have gone wrong with the invasion. On the other hand, Red might with much more wisdom have waited till that command was assured.

With regard to attacks on unfortified towns, Red soon discovered that it was hardly worth the expense and risk to so employ warships. Blue recognized this all along, and with a thorough and complete system made his attacks with armed liners that he did not contemplate using for any other purpose. The loss inflicted on Red was heavy, and the attempt to stop this privateering only very partially effectual.

The slow armored gunboat proved absolutely useless, though its presence on the West Coast might possibly have served some purpose had the "Hermione" attacked towns there.

The destroyers were singularly unlucky, two being ingloriously disposed of through their own carelessness; only the "Earnest" met with what may be termed an "orthodox fate." The presence of the "Seagull" in the Channel confined the "Boxer" to port during the invasion operations. She made no attempt against either colliers or liners. It is true that these always passed the danger points in daylight, and on one day the weather was unsuitable for destroyers to go out; but it is not apparent that the possible argument, that "the more Red landed at Falmouth, the more there would be to capture," had weight in this, or else Blue would hardly have gone to the expense and risk of sending out the "Grosiatschy." It is more likely that the risk of destruction by the "Seagull" was considered too great to render any attempts worth while under the circumstances. Neither side attempted to attack any fortified place.

By the "terms of peace," Blue retained all captured ships, and recovered those that had been taken—"Thunderer" and "Cristobal Colon"—leaving the Reds with only the "Hermione," one liner, and one torpedo boat. At some future time a *guerre de revanche* is contemplated, each side being allowed to add a certain amount in tons of shipping, the types to be by choice from any existing warships; and this problem of absolutely disproportionate forces may present some very interesting subjects for solution. At present, however, arrangements are in progress for a Spanish-American war, with special reference to the coal question. Saving that the positions of ships must correspond to the actual positions when the Spanish ambassador left Washington, the rival sides may make whatever moves they consider best. Lieut. Kawashima will conduct the Spanish operations, mainly with the idea of working out a plan whereby, in his opinion, Spain would be the principal gainer. Of this plan the American side is to be, of course, entirely ignorant; but in order to test the matter to the fullest, America will be allowed to choose an alternative solution in the case of any selected proving a mistake. Speeds, coal endurance, and resources generally will be the actual ones, the armor and armament of all ships will probably be kept on a system of prearranged tactical units, in order to keep the result purely strategical. Should America win, not very much will necessarily be proved; but should Spain be victorious, the result should certainly be indicative of possibilities. Several players will probably be selected to represent the United States Navy Board.—Engineer.

RESTORING BURNT STEEL.

THERE are several means for doing this, says The Werkmeister Zeitung. The so-called regeneration of burnt steel is most simply accomplished in the following manner:

Heat the steel several times to a dark red, and quench after each heating in hot water. The steel finally recovers its former qualities. The first heating and quenching has the strongest effect, which gradually becomes weaker, until after the fourth or fifth treatment the steel is affected no longer. From this it is evident that three or four temperings are usually sufficient. By examining the fracture surface of steel thus regenerated it will be found that its grain has become as fine as it was before burning; in fact, its structure is identical with that of similar steel hardened but which has not suffered any previous burning. It is, however, always to be understood that the above mentioned chemical change of the steel in regard to its carbon contents has not taken place simultaneously with its burning. In this case this simple tempering method is of no avail, and the steel has to be subjected to a different treatment, according to the circumstances. If the steel has absorbed too much carbon, it should be heated slowly, allowing free access of air; if it has lost too much carbon, it has to be recarbonized before harden-

ing. This is accomplished by putting the tools or other steel articles to be treated into boxes of sheet iron or crucibles and embedding them either singly or collectively in powdered bone or charcoal. After the boxes or crucibles have been closed tightly, these, together with the contents, are heated for about one hour, when the articles are taken out and tempered in water. Frequently heating in closed vessels is dispensed with, and simple hardening means applied to the articles. In this case, for instance, ferrocyanide of potash can be sprinkled on the articles after they have been heated to a brown red, and they are then tempered in water.

A number of means for regenerating burnt steel are in use, and either one or the other is recommended by their respective champions; some favor pure water, but others prefer stronger mixtures, of which we give a few receipts:

(1.) Ten parts of resin, 5 parts of fish oil, 3 parts of mutton fat.

When employing this mixture the steel is heated to a dark red, and quenched in the molten liquid, after which it can be tempered in the usual manner.

(2.) Ten parts of mutton fat, 10 parts of linseed oil, 1 part of lampblack.

This mixture is melted, and the heated steel is dipped into it for one minute.

TORPEDO DISCHARGE TUBES.

THE following article is, with few alterations, a reprint of a report and description recently prepared by Sir William Armstrong, Whitworth & Company of their new torpedo discharge tube. We have thought it advisable, says The Engineer, in which the article appears, to give it in its original form, with the omission of certain parts, so that it may be regarded as official; only in the description of the tube itself we have found it necessary to supplement the original report in a few places:

The dangers which attend the use of above-water torpedoes are well known. It has therefore always been recognized that torpedoes should be kept below the water line and discharged from submerged tubes or guns, but the difficulties of carrying this out in practice have also been considered as almost insurmountable.

In the first place, the problem is not one to be worked out only in a drawing office. Experiments and practice are necessary in order to verify calculations and to obtain experience. But to make experiments it would be necessary to employ a large ship capable of steaming at high speed. This ship would have to be docked, not only when first fitting the submerged apparatus, but also after any accident which might occur during the experiments. The mere running of the ship at high speed would be a most costly matter, and taken altogether, the cost of producing a submerged torpedo apparatus has appeared so formidable as to check all private manufacturers, however strong their desires may have been to solve the problem. That these apprehensions were justified is beyond dispute, for it is no secret that the English submerged torpedo tube—the first, and indeed, only one, in successful operation before the introduction of the Elswick tube—cost in its production a sum which very few other nations could have afforded.

But after the Chino-Japanese war all governments, when demanding designs for new warships, made it almost a sine qua non that the torpedoes should be discharged from below water. The problem, therefore, had to be faced, and this was accordingly recognized at Elswick.

In the latest pattern of English submerged tube three separate operations are necessary each time the torpedo is ejected. 1. the bar or shield—which corresponds to the Elswick spoon—has to be run out; 2, the torpedo has to be ejected; 3, the bar has to be withdrawn. When the Elswick design was prepared, it was determined to try and combine all three motions.

It will be observed that if the shield, bar, or spoon and the torpedo be ejected together, there may always be the risk of some cause impeding the shield while the torpedo pursues its course. The torpedo guides under such circumstances would leave the grooves in the shield before the latter was entirely out, and the torpedo would certainly be injured or deflected abnormally. But in the Elswick design this cannot happen, for the two actions—those of running out the shield and ejecting the torpedo—are separate, but they follow each other automatically in proper order and place, although only a single motion is necessary on the part of the operator.

A cordite discharge for above-water torpedoes had been very successfully worked out at Elswick, and it was determined to embody this arrangement if possible

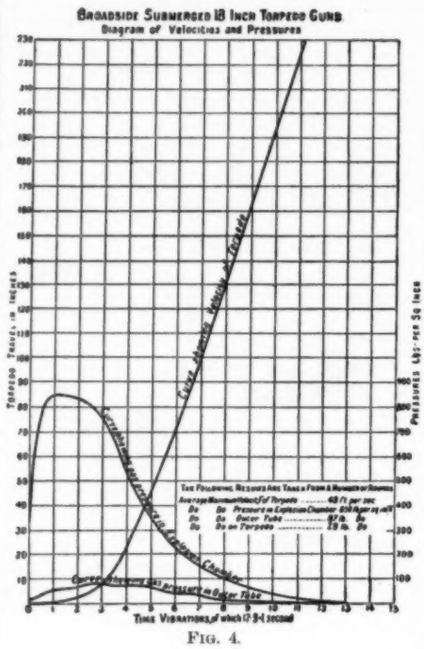

BROADSIDE SUBMERGED 18 INCH TORPEDO GUNS
Diagram of Velocities and Pressures
TORPEDO TRAVEL IN INCHES
PRESSURES LBS. PER SQ INCH
TIME VIBRATIONS, OF WHICH 17 = 1 SECOND

FIG. 4.

in the design for submarine discharge. It is not, however, claimed that there is great advantage in cordite discharge over air discharge. Cordite is always ready for use, and it has been shown to give very even results. The firing arrangements with cordite discharge are also very simple; they are, in fact, precisely similar to those which have been so long in use, and are so thoroughly reliable with ships' artillery. With the Elswick submerged tube the use of cordite makes the automatic withdrawal of the spoon after ejection of the torpedo much more perfect; for the gases cool rapidly and so lose much of their pressure, which would otherwise balance the pressure due to the head of water tending to force the tube in. But for air discharge it may be claimed that compressed air will always be available as long as torpedoes derive their motive power therefrom. It only takes a few seconds to charge the impulse reservoir, and air is always procurable, whereas cordite may not be. A large proportion of the Elswick tubes are fitted for both air and cordite impulse.

With these principal points in view the Elswick design was undertaken, and in order to save time and cost, a model, quarter size, was made for experimental purposes. This model—Figs. 1 and 2—was attached to the side of a large tank, and close to its orifice a vertical column was erected. Sluice valves were also fitted, so that the water in the vertical column might, by simultaneously opening the sluices, be suddenly allowed to rush past the model submerged tube, entering into the tank on one side and leaving it on the other. Thus, instead of the ship with the submerged tube passing through the water, the water was made to pass the submerged tube. The vertical column was made of sufficient height and capacity to insure a large volume of water passing the tube at a speed of rather over 20 knots per hour. An automatic arrangement fired the torpedo through this passing stream just when it acquired its highest velocity. The water was let loose by releasing the ball, B, which in falling jerked the levers which held the sluices shut. The float, A, in falling with the water, lifted a brass ball between two contacts, which automatically closed the firing circuit. Although the results from this arrangement could not be considered conclusive, yet they led to most useful information, and gave confidence to the designers. Then, when a full-sized submerged tube was constructed, a large tank was made, and a full-sized dummy torpedo was ejected round after round, until all the points connected with submarine discharge from a ship at rest were settled, for it was found impossible to repeat the passing water experiment on a full-sized scale.

In the meantime the firm had undertaken to equip two Japanese ironclads, the "Fuji" and "Yashima," with submerged tubes, and before these tubes had been erected on board orders had also been received for submerged tubes from the Norwegian, Chilean, Brazilian, and Portuguese governments. For submerged practice it is necessary to fit the torpedoes with guides, as shown in Fig. 3.

A torpedo was thus fitted at Messrs. Whitehead's works, Portland, and sent to the "Fuji," which battleship, after taking part in the naval review, had gone to Portland. On July 14 her trials took place. Only one, the port forward submerged tube, was employed. A round at 12 knots was first fired with a dummy, the tail of which was misshapen before the torpedo was put into the tube. It was not thought that this would be of much consequence, but in its bent condition it lacked strength to take the strains, especially as no intermediate guide was fitted to the torpedo. The result, however, proved instructive, for the tail jammed itself so firmly in the tube that, although it was nearly wrenched off, it stopped the torpedo, which remained in the spoon or shield, the guides on the torpedo being just at the end of the grooves. In this position it would produce the maximum strain on the guide. But although the ship had a speed of 12 knots, the inner tube ran in automatically, and was in no way damaged. A small charge completed the ejection of the damaged dummy. The real strengthened torpedo was then used, and rounds were fired at 5 knots, 10 knots, 12 knots, and 16 knots with complete success. Captain Gallwey, of the Whitehead works, was on board the "Fuji," and reported that no distortion whatever had taken place to any of the parts, the torpedo being as accurately in line as when it left Messrs. Whitehead & Company's works. With regard to the submerged tube, the speed of the ship did not apparently affect it in any way. The ejection was regular, and automatic return took place after each round. The tubes were found to be very easy and handy to work. It will be noted that the same torpedo was used in all these runs without being overhauled between the runs. Further, very successful trials were conducted off the mouth of the Tyne from the "Yashima," and at Horten, in February last, from the "Harald Haarfagre." Results of the former are given in Table A.

Throughout the practice there was no difficulty or hitch in the working of the torpedo tubes. The return was always automatic, and the tubes came to rest quite quietly against the rear stops. The new electric circuit was found most convenient. One misfire occurred on account of a fault in the striker. Steps will be taken to prevent a recurrence of this in future. The diagrams, Figs. 4 and 5, show the water pressures in the inner tube and the gas pressures between the tubes.

The Elswick submerged torpedo tube—Figs. 6 and 7—consists of three principal parts, the outer or fixed tube, A, the inner or movable tube, B, and the sluice valve, C. The inner tube is made in two parts, known respectively as the spoon and rear end, which are firmly bolted together—indeed, they are only separated for manufacturing purposes. The spoon is made of a spe-

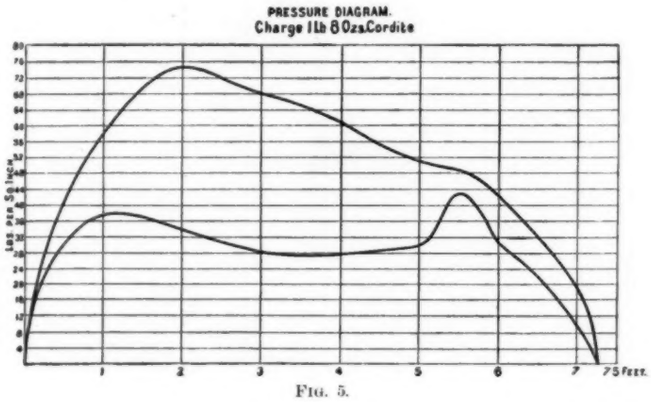
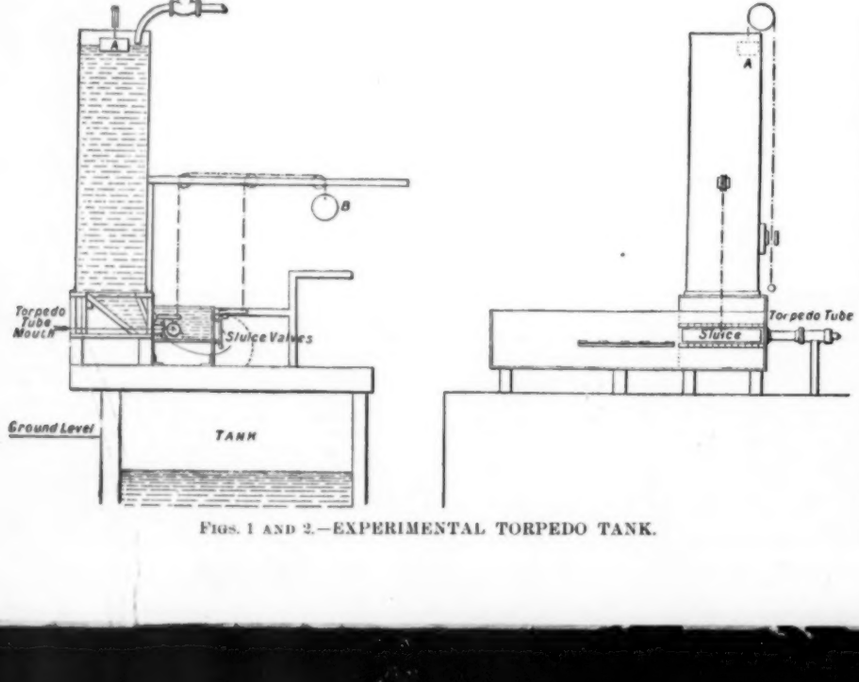


FIG. 5.



FIGS. 1 AND 2.—EXPERIMENTAL TORPEDO TANK.

TABLE A.

Tube.	Torpedo.	Speed of ship.	Range.	Remarks.
			yards.	
Starboard	Dummy	Anchor	—	Torpedo travelled under water quite 100 yards.
Starboard	Dummy	Anchor	—	Torpedo travelled about 90 yards.
Starboard	Dummy	Anchor	—	Torpedo travelled about 90 yards.
Starboard	No. 5661	Anchor	—	Very good run.
Port	Dummy	Anchor	—	Torpedo travelled about 100 yards.
Starboard	No. 5661	9 knots	300	Torpedo passed under right-hand flag of target. There was a strong tide running from right to left, for which 2 deg. were allowed, assuming that the ship would pass 500 yards from the target. Had she done so the torpedo would have passed under the centre flag.
Port	No. 5659	12·8 knots	450	Torpedo fitted with Obry apparatus, 2 deg. allowed for tide. Very good run, torpedo passing under centre of target.
Port	No. 5662	14·8 knots	500	Torpedo fitted with Obry apparatus, 2 deg. allowed for tide. Very good. Torpedo passed under the left-hand flag.
Starboard	—	15·5 knots	420	No Obry apparatus. Torpedo passed to the right of the target, not sufficient allowance having been made for tide.

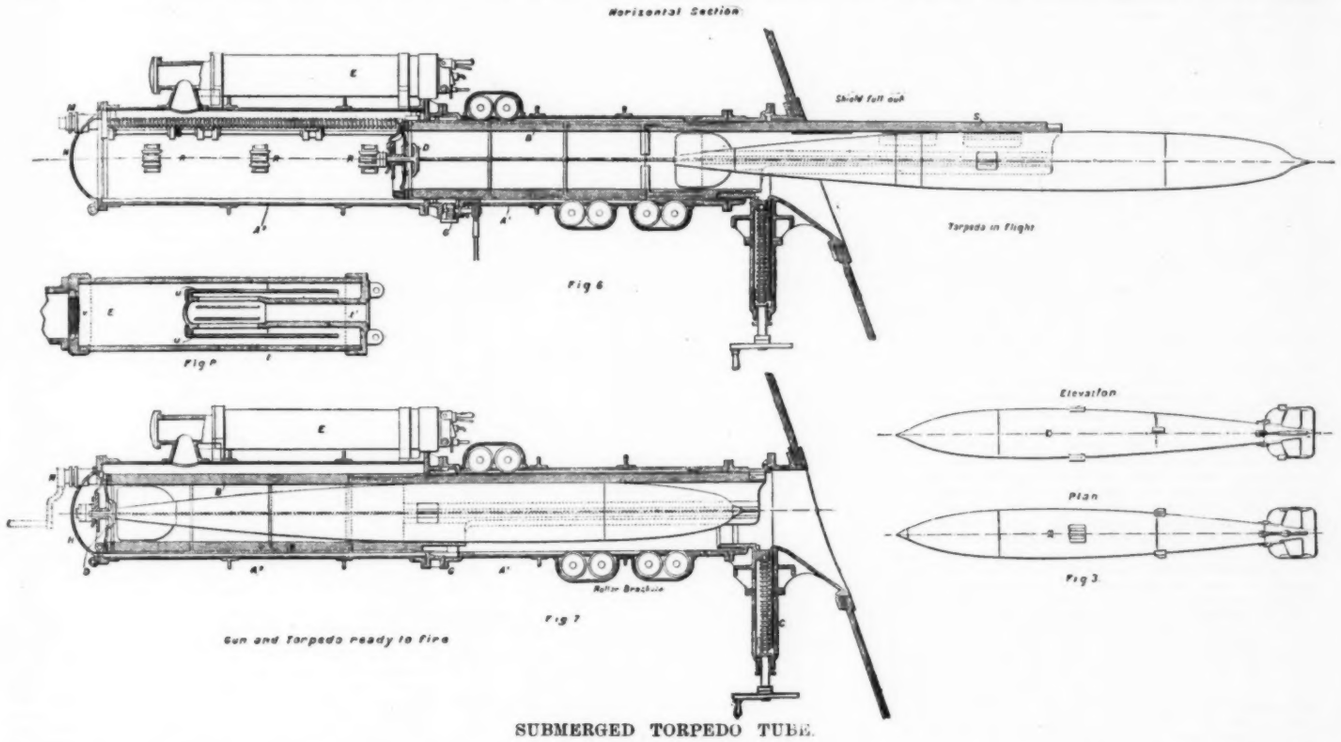
cial alloy of copper known as Elswick bronze, which is peculiar for strength. The rear end is made of gun metal. When joined together the grooves for carrying and supporting the torpedo run from one end of the rear end to the other end of the spoon. The rear end is a simple cylinder in shape: it is fitted with a door at one end: this door carries the axial valve, D, through which the gases pass to eject the torpedo. The spoon or shield, S, resembles a half cylinder, and is of such a length that the torpedo guides clear the grooves and the tail clears the sluice valve at the same moment. It is made with orifices in it wherever strength will permit, the object of these orifices being to allow water to pass through on to the torpedo, and so help to balance the pressure exerted on the head when the torpedo is being ejected with the ship steaming. The orifices also help to lighten the spoon. The outer tube is in four parts, the front outer tube, A^1, the gland box, G, the rear outer tube, A^2, and the explosion chamber, E. The front outer tube is a steel cylinder fitted with flanges at the ends; one flange bolts on to the sluice valve casing, the other to the gland box. Inside, the front outer tube has brass guides and rollers on which the inner tube travels, and outside this tube are fitted drain cocks and pipes for emptying the tube when the sluice valve is closed, also air cocks to let air escape when filling. The gland box carries the gland ring and the mechanism for externally adjusting the gland which packs the rear end of the inner tube. The rear outer tube, made of steel, is fitted at its rear end with a door known as the outer door, H, in distinction to the door on the inner tube, which is known as the inner door. Like the front outer tube, the rear outer tube is fitted with guides and rollers, R R R, to take the inner tube. It also carries inside it the hand running in and out gear, and the cam plate for regulating the axial valve, D. The explosion chamber, E—Figs. 6, 7, 8—for use with cordite impulse, is carried on the top of the rear outer tube, a large connecting pipe being provided to convey the gases produced by the explosion of cordite into the rear outer tube.

The cartridge is placed in the chamber, t^1, which is closed, and fired by suitable mechanism. To moderate the rush of gas resulting when the charge of cordite or other explosive is ignited, the gas is checked and baffled by being made to pass through perforations in a plate and to flow in a circuitous course. The annular space within the casing serves as an expansion chamber for the gases, and the gases when in this chamber exert a pressure in rear of the inner tube and drive it forward. If air impulse be required, a reservoir of tubes is placed on the top of the rear outer tube, and the air inlet valve is fitted between the reservoir and the connecting pipe. The sluice valve is worked by the usual screwed shaft. An indicator shows the position of the valve, and an electrical safety arrangement makes it impossible to fire the torpedo unless the valve be properly opened.

The submerged torpedo tube is worked as follows: The sluice valve being closed, the inner tube of course being right in—Fig. 7—both inner and outer doors, on the rear ends of the inner and outer tubes, are opened. The torpedo is pushed into the inner tube until the guide on the torpedo takes against the stop in the tube. The air lever will be just behind the position of the air tripper. The inner door is then closed and made watertight by means of the clamps. The act of shutting this door puts the air tripper into position for engaging the air lever directly the torpedo starts in the inner tube. As soon as the inner door is closed the sluice valve may be opened, and while this is being done the outer door should be closed and secured. The cartridge with cordite charge may be placed in the explosion chamber directly the sluice valve is open. Lastly, the cartridge chamber door is closed, and all is in readiness for firing.

The electric firing circuit is arranged so that each cartridge is automatically tested directly it is placed in the chamber. Automatic indications are also given in the conning tower to show (1) when the sluice valve is opened, (2) when all is in readiness for firing. When the firing key is pressed, the cordite charge will explode or the compressed air will be released with a consequent pressure in the rear outer tube, which, as already explained, acting on the rear end of the inner tube, forces it out with the spoon—Fig. 7. As the axial valve is closed during the first part of the motion of the inner tube, the gas pressure cannot act directly on the torpedo; the latter, therefore, just moves forward as an integral part of the inner tube. After the inner tube has moved forward a short distance, the axial valve is allowed to open a little; thus gas passes through and starts the torpedo in relation to the inner tube. When the latter is nearly out in its extreme position, the axial valve is opened fully, the gases—very much reduced in pressure on account of the expansion which has taken place—pass through and eject the torpedo. A reaction then takes place. If cordite impulse has been used, the gases cool rapidly, and the pressure in rear of the inner tube becomes reduced. The pressure due to the head of water, therefore, is unbalanced and forces the tube in again. When air impulse is used the tube will remain out until a small valve, supplied for the purpose, is opened to allow the pressure to escape. If for any reason the tube does not automatically return—experience has shown that this contingency is very rare indeed—it is not the work of a minute to throw the hand gear into action, and the tube can then be drawn in. Arrangements are made to control the pressure in rear of the tube so that it shall come to rest gently. As soon as the tube is in, the sluice valve should be closed and the drains opened. The tube is then emptied, after which it is ready for another torpedo.

It only remains to be said that the submerged tubes are amply provided with appliances and means for taking them to pieces for examination and cleaning purposes, and with lubricators. All working parts which come in contact with sea water are made of gun metal. The weight of a 5 m. 18-inch torpedo tube is about seven tons. If this be compared with the weight of an above-water tube, it will be found that there is only an addition of about two or three tons for the submerged tube. An above-water tube, with its mouthpiece and other fittings, can hardly be installed on board a ship for less than two tons; then, recently, all such tubes have been protected by armor, and in this way it is not uncommon to find that three tons have been employed, bringing the total weight of the above-water torpedo tube up to five tons. When the great advantage of the submerged discharge over the above-water discharge is considered, this extra weight of two tons will not appear to be great.



SUBMERGED TORPEDO TUBE.

NEWFOUNDLAND'S RAILWAY COMPLETED.

THE Newfoundland Transinsular Railway is now an accomplished fact, the last irons being laid last fall. The line extends from St. John's, the capital, on the eastern coast, to Port-au-Basques, at the southwestern extremity of the island, fifty miles from Cape Breton, and its completion marks an era not alone in the history of this colony, but in that of British North America also. With the accomplishment of this undertaking, a line of railroad will unite all England's possessions in this quarter of the globe, stretching from the Atlantic to the tidewaters of the Pacific, unbroken save at Cabot Strait, between Port-au-Basques and Sydney, which area of waters will be bridged by a fast ferry steamer, covering the distance in six hours. The transatlantic traveler from Liverpool, landing at St. John's, can board the train here, change to the steamer at Port-au-Basques and rejoin the train at Sydney, thence traveling by the Intercolonial and Canadian Railways and their connections to any part of the American continent. The equipment of the line is first-class in every respect, the trip across the island will be made in twenty-four hours, and people here will enjoy the hitherto unknown blessings of a tri-weekly mail, as against a fortnightly one, as we have now.

The line is narrow gage (3 feet 6 inches), laid with fifty pound rails, and built by R. G. Reid, of Montreal, who built much of the Canadian Pacific road. All the bridges are of steel, with native granite piers and abutments, laid in best masonry, and the trains will be fitted with sleeping and dining cars. For the accommodation of tourists, large hotels are to be built at suitable points along the line.

It is now an interesting question whether the experiment will be successful or not. The main or through line is 547 miles long, with a branch line of 29 miles to Brigus, Harbor Grace and Carbonear, another of 26 miles to Placentia, and a third of 12 miles to Notre Dame Bay. The total mileage is about 615 and the cost is $15,600 per mile, a total of $9,594,000. There remain stations, terminals, and docks to be built yet, which will increase by $500,000 the colony's total outlay for railway purposes. This $10,000,000 is rather more than half our entire public debt, and the annual interest charge on account of the railway alone will be $350,000 out of a total interest payment per year of about $700,000.

This is a serious financial obligation to face when it is considered that our population is only 200,000 and that there has been no appreciable increase the past ten years, during which period this road has been under construction. Now that it is completed, two questions suggest themselves: What is to be done with the laborers, and how is the road to be made to pay? The original idea of the railroad, it may be said without hesitation, arose from the idea of providing a means of employment. When the policy of railway construction was adopted, fifteen years ago, the reason assigned was that the fisheries were becoming inadequate to support the population, and that new avenues of industry had to be found for those who could no longer continue thereat. Since then the building of the railroad has provided employment each summer for 2,000 to 3,000 men, and the glut in the labor market has thus

been relieved. Now that the road is finished, there is no more work for them, nor any immediate prospect of their procuring it in other directions.

For the next seven years the colony will not be directly concerned in the working of the line, as Mr. Reid, the contractor who built it, has to operate it for that period, receiving as a subsidy for so doing a grant in perpetuity of 5,000 acres for each mile of road. But that they had no bright hopes of its paying for some years after that is evidenced by the fact that in the confederation proposals at Ottawa in April, 1894, our delegates estimated for a shortage of $150,000 per year on account of working the road. The line, however, offers considerable prospect of creating industries that may attain to some dimensions in the course of a few years. There is lumbering, which has already become so important that there is not a piece of board imported into the country now, while millions of feet are annually sent to Britain and America. The manufacture of pulp is also likely to be a factor in our future development.

The interior of the island, up to this time an uninhabited wilderness, because of the difficulties of communication, is seamed with great rivers, the banks of which contain large areas of splendid agricultural land. There are other tracts of pasture land which competent authorities say will be able to support thousands of cattle. Oxen could be fed as cheaply here as in the Western United States, and the sea voyage from here to England would be only four days, as against eight to twelve from Montreal or American ports. The copper and pyrites deposits in Notre Dame Bay are among the richest in the world, and Bell Island, in Conception Bay, has a hematite deposit from which 50,000 tons per year are being taken. Along the west coast we have more hematite, chrome iron, asbestos, gypsum and petroleum, and the recent discoveries of coal at Codroy promise to revolutionize the coal trade of the St. Lawrence shipping. The coal is only twenty miles from Port-au-Basques, and every steamer going up and down the river by Cabot Strait, the southern entrance, passes within sight of it, so that it is more than likely they would coal there instead of going ninety miles out of their way to reach Sydney, C. B. Should all these projects matefialize, the colony ought to take an upward step.

LIQUID HYDROGEN.

A VERY remarkable achievement, which will redound to the credit of English science, has been performed within the walls of the Royal Institution. For some time past it has been a matter of general knowledge that Prof. Dewar has been preparing for an attempt to produce liquid hydrogen on a large scale. Money has been freely subscribed for investigations to be carried on at low temperatures, and the laboratories of the Royal Institution have gradually approached more and more nearly to the likeness of an engineering workshop. Very grave difficulties had to be encountered, and success seemed long in coming; but on Tuesday, May 10, says Nature, Prof. Dewar was able to inform the president of the Royal Society that on that day both hydrogen and helium had succumbed to his attack.

All this is typical of British methods. The members of a great private institution have secured the services of a man in whose abilities they believe. They supply him freely with the sinews of war, and he justifies their confidence by achieving a success which, as far as our present knowledge goes, could only have been won by a combination of great resources and very great skill. We heartly congratulate Prof. Dewar and his supporters on this result, and on the fact that the world now possesses liquid hydrogen—so to speak—on tap.

The conditions of the experiment give some idea of the difficulties which have been overcome. Hydrogen cooled to —205° C. escaped, under a pressure of 180 atmospheres, into a vacuum vessel surrounded by a space which was itself maintained at a temperature of —200° C. Thus constrained it liquefied.

About 20 c. c. of the liquid were collected in another protected vessel, into which it dripped from that above described. It is transparent, colorless, with a well-defined meniscus, and apparently with a relatively high refractive index.

We sincerely hope that this great success will not be marred by a controversy as to priority, of which some symptoms have already appeared in a leading article in The Standard and elsewhere. The time is long past in which the liquefaction of a gas was interesting as proving that under proper conditions all substances can be liquefied. For many years nobody has had doubts on that point. We have learned to look upon the liquefaction of a gas as important, mainly because it affords a means of studying at very low temperatures not only the liquefied gas itself, but also other kinds of matter. Experiments in which momentary liquefaction is attained are chiefly interesting as showing that some approach is made to realizing the condition under which more stable results may be expected. They take a much higher rank if the skillful experimenter can wrest from the substance in a transitory condition some information as to the properties which the material would have if it were reduced to the state which has been called a "static liquid." To attain these results in the case of so intractable a substance as hydrogen is an achievement of a very high order. But when this has been done it cannot be fairly contended that all the rest follows as a matter of course.

There have been discoveries in which the first step was all-important. The discovery, for instance, of the Roentgen rays opened an entirely new range of facts to scientific investigation. In other cases the root-idea had long been common property, and the merit, like that of Captain Bunsby's observation, "lays in the application of it." It has long been known that if hydrogen were ever liquefied in quantity, both cooling to a very low temperature and a rapid expansion would play a large part in the operation. The difficulties of the experiment lay, not in understanding these principles, but in applying them, and the difficulties were so enormous that the investigator who has overcome them deserves our admiration. He has performed not only a great "tour de force," but has cleared the way to a region hitherto unexplored, to a whole series of researches which become more interesting and important as the absolute zero is more nearly approached.

It appears to us, therefore, that there is no necessity to belittle the work either of Prof. Dewar or of others who have been active in the same line of research. Cailletet and Wroblewski obtained results which, to judge from his address to the French Academy, reported in The Times of May 17, are regarded as inconclusive by so high an authority as M. Moissan. At the best, and assuming the liquid obtained to have been hydrogen, its existence in the liquid form was very brief. Prof. Olszewski also has published a full account of how he obtained hydrogen for a moment in a mistlike state, in which he measured some of the constants of the liquid. Yet nothing but the paucity of language could lead to the idea that this feat was the same as that which Prof. Dewar has accomplished. Had we no other evidence of the existence of water, something might be learned from the study of clouds; but nobody contends, on that ground, that a cloud is the same thing as a duck pond. Yet the difference between the two is hardly, if at all, greater than the practical difference between hydrogen without visible form or surface, in a state of momentary or "dynamical" liquefaction, and hydrogen as a "static" liquid, with a clearly defined meniscus, boiling away quietly under conditions which enable the observer to record its appearance, to handle and to use it.

By insisting on this difference, we do not for a moment wish to question the merits of Prof. Olszewski's work. He used the means at his disposal admirably, and made measurements of the critical temperature and boiling point of hydrogen, which, tested as they were by check experiments on oxygen and ethylene, were of great value.

Prof. Olszewski was, however, fully conscious of the difference between these results and those which Prof. Dewar has now achieved. He again and again explained with the utmost candor that he had seen no meniscus, and that he had failed to reduce hydrogen to the state of a "static liquid." He further expressed the opinion that these desiderata would not be attained until a cooling agent was discovered in the form of a gas, with a density between those of hydrogen and nitrogen. No such gas has been used by Prof. Dewar, yet hydrogen has now been seen by himself, by Lord Rayleigh and others as a well defined liquid mass. The merits of this achievement will be in nowise diminished by a generous recognition of the researches of Olszewski, but on the other hand it would be most unfair to minimize the magnitude of Prof. Dewar's success by classing it merely as a repetition, on a larger scale, of another man's work. It is in the words of M. Moissan a "wonder of modern chemistry."

The following abstract of the paper will give further details:

In a paper entitled "The Liquefaction of Air and Research at Low Temperatures," read before the Chemical Society, and published in the Proceedings, No. 158, an account is given of the history of the hydrogen problem and the result of my own experiments up to the end of the year 1895. The subject is again discussed in a Friday evening lecture on "New Researches on Liquid Air" (Roy. Inst. Proc., 1896), which contains a drawing of the apparatus employed for the production of a jet of hydrogen containing liquid. It was shown that such a jet could be used to cool bodies below the temperature that could be reached by the use of liquid air, but all attempts to collect the liquid in vacuum vessels failed. No other investigator has so far improved on the results described in 1895. The type of apparatus used in these experiments worked well; so it was resolved to construct a much larger liquid air plant, and to combine with it circuits and arrangements for the liquefaction of hydrogen, which will be described in a subsequent paper. This apparatus, admirably constructed by the engineers, Messrs. Lennox, Reynolds and Fyfe, took a year to build up, and many months have been occupied in testing and making preliminary trials. The many failures and defeats need not be detailed.

On May 10, starting with hydrogen cooled to —205° C., and under a pressure of 180 atmospheres, escaping continuously from the nozzle of a coil of pipe at the rate of about 10 cubic feet to 15 cubic feet per minute, in a vacuum vessel double silvered and of special construction, all surrounded with a space kept below —200° C. Liquid hydrogen commenced to drop from this vacuum vessel into another doubly isolated by being surrounded with a third vaccum vessel. In about five minutes, 20 c. c. of liquid hydrogen were collected, when the hydrogen jet froze up from the solidification of air in the pipes. The yield of liquid was about one per cent. of the gas. The hydrogen in the liquid condition is clear and colorless, showing no absorption spectrum, and the meniscus is as well defined as in the case of liquid air. The liquid must have a relatively high refractive index and dispersion, and the density must also be in excess of the theoretical density, viz., 0·18 to 0·12, which we deduce respectively from the atomic volume of organic compounds, and the limiting density found by Amagat for hydrogen gas under infinite compression. My old experiments on the density of hydrogen in palladium gave a value for the combined body of 0·62, and it will be interesting to find the real density of the liquid substance at its boiling point. Not having arrangements at hand to determine the boiling point, two experiments were made to prove the excessively low temperature of the boiling fluid. In the first place, if a long piece of glass tubing, sealed at one end and open to the air at the other, is cooled by immersing the closed end in the liquid hydrogen, the tube immediately fills, where it is cooled, with solid air. The second experiment was made with a tube containing helium.

The Cracow Academy Bulletin for 1896 contains a paper by Prof. Olszewski, entitled "A Research on the Liquefaction of Helium," in which he states "as far as my experiments go, helium remains a permanent gas, and apparently is much more difficult to liquefy than hydrogen." In a paper of my own in the Proceedings of the Chemical Society, No. 183 (1896–97), in which the separation of helium from bath gas was effected by a liquefaction method, the suggestion was made that the volatility of hydrogen and helium would probably be found close together, just like those of fluorine and oxygen. Having a specimen of helium which had been extracted from bath gas, sealed up in a bulb with a narrow tube attached, the latter was placed in liquid hydrogen, when a distinct liquid was seen to condense. From this result it would appear that there cannot be any great difference in the boiling points of helium and hydrogen.

All known gases have now been condensed into liquids which can be manipulated at their boiling points under atmospheric pressure in suitably arranged vacuum vessels. With hydrogen as a cooling agent, we shall get within 20° or 30° of the zero of absolute temperature, and its use will open up an entirely new field of scientific inquiry. Even as great a man as James Clerk Maxwell had doubts as to the possibility of ever liquefying hydrogen (see "Scientific Papers," vol. ii., p. 412). No one can predict the properties of matter near the zero of temperature. Faraday liquefied chlorine in the year 1823. Sixty years afterward Wroblewski and Olszewski produced liquid air, and now, after a fifteen years' interval, the remaining gases, hydrogen and helium, appear as static liquids. Considering the step from the liquefaction of air to that of hydrogen is relatively as great in the thermodynamic sense as that from liquid chlorine to liquid air, the fact that the former result has been achieved in one-fourth the time needed to accomplish the latter proves the greatly accelerated race of scientific progress in our time.

The efficient cultivation of this field of research depends upon combination and assistance of an exceptional kind; but in the first instance money must be available, and the members of the Royal Institution deserve my especial gratitude for their handsome donations to the conduct of this research. Unfortunately, its prosecution will demand a further large expenditure.

During the whole course of the low temperature work carried out at the Royal Institution, the invaluable aid of Mr. Robert Lennox has been at my disposal; and it is not too much to say that but for his engineering skill, manipulative ability and loyal perseverance, the present successful issue might have been indefinitely delayed. My thanks are also due to Mr. J. W. Heath for valuable assistance in the conduct of these experiments.

REFUSE DESTRUCTION.

THERE is now a pretty general consensus of opinion that the most sanitary way of destroying organic matter is to consume it, and the municipal engineer has now a choice of three or four different and, on the whole, efficient forms of refuse destructors. The uninitiated, it is true, often make the complaint that this involves the loss of matter which should be of great value for agricultural purposes; but experience has shown that there is no demand of any importance for the material in question, or even for the still more suitable pressed sludge cake which forms the solid residuum left at sewage precipitation works. Practically everywhere these wastes cannot be sold in any considerable quantity, and hence most municipalities have been forced to abandon the attempt and treat such residues of our civilized life as mere noxious matter to be got rid of as cheaply and safely as possible. It must be admitted that, as concerns what is generally known as dust, many commercially valuable commodities may be rescued by a process of hand picking; but how far this course is justifiable from a hygienic point of view is, in most cases, very debatable. However that may be, there must always remain a very large proportion of utterly valueless and noxious material, with reference to which the best that can be said is that it has a certain fuel value. Regarded commercially, however, there has in recent years been a decided tendency to overrate this, since the first essential of a destructor is that it must destroy completely, allowing no fumes to pass into the outer air and thus create a more or less serious nuisance.

To secure this end, destructors, it is found, must be worked with great regularity, while, in general, demands for steam raised by the heat resulting from this destruction are variable. In practice, the latter must, accordingly, be subordinated to the main business of destruction, and the amount of power commercially available is correspondingly diminished. Nevertheless, a very fair amount of steam may be raised without compromising the proper working of the refuse plant, as is shown very clearly by the tests carried out by Sir Douglas Fox with the Beaman & Deas destructor, which was erected at Leyton some little time back. We have already described this plant in detail (see Engineering, vol. lxii., p. 671), and a peculiar interest attaches to it in that it was the first at which the burning of sewage sludge was undertaken. The waste heat is used to raise steam in two 96 horse power Babcock & Wilcox boilers, and the tests referred to were made to determine the available heating power of the refuse used. The latter consisted of ordinary house refuse and cakes of sewage sludge from the filter presses of the Leyton precipitation works. This sludge contained from 61 to 68½ per cent. of moisture and but 6½ per cent. of combustible carbon. The house refuse was of low fuel value, the quantity of cinders being small; and during the trial, which lasted twelve hours, the cells were fed with a mixture of one part of the sludge to two parts of the house refuse. In the time named 22 tons 2 cwt. of the latter and 11 tons 9 cwt. 1 qr. of the former were consumed, with the production of 9 tons 16 cwt. 2 qr. of clinker and an equivalent evaporation of 0·507 pound of water per pound of the mixture supplied. An analysis of the furnace gases showed that the combustion was extremely complete, the presence of CO being only noted once, and then in the insignificant quantity of one-fifth of one per cent. The temperature reached in the combustion chamber was 1,562 degrees F.—Engineering.

Grain is being carried from Chicago to New York, all rail, for 10 to 12 cents per 100 pounds, according to The Financial Chronicle. Taking the distance from Chicago to New York at 1,000 miles, it is seen that 10 to 12 cents per 100 pounds for a haul of this length is equivalent to only 2 mills to 2·4 mills per ton mile. But it is also stated that even this low rate includes a charge of 3 cents per 100 pounds lighterage in New York Harbor, making the total rate for the railway haul from Chicago to New York only 7 to 9 cents, or 1·4 mills to 1·8 mills per ton mile. We know of no lower rate than this having ever been made for railway freight transportation, says Engineering News, and the puzzling thing is that railway traffic managers should accept business at such figures, which must be well below the actual cost to the railway company, so that it could actually show a better balance-sheet at the end of the year by refusing the shipments.

ENGINEERING NOTES.

The Locomotive publishes a summary of boiler explosions for 1897, in which it is shown that there were a total of 369 explosions during the year, in which 398 persons were killed and 528 injured. The total explosions in 1896 were 346, with 382 killed and 529 injured.

The Richmond Locomotive Machine Works have recently received by cable an order from the Finland (Russian) State Railway for seventeen compound locomotives. The works are without influence in Russia, and say the order is given upon the merits of their workmanship.

Sweden is going to build a railroad from the head of the Gulf of Finland to the Ofoten Fiord, on the Norway coast, 120 miles north of the Arctic Circle. The line to the Gellivare mines will be used, and a branch run from the present northern end of the Swedish railroad system to Tornea, on the Finland Gulf." The extension is made chiefly for strategic reasons.

Consul-General Goldschmidt, of Berlin, under date of March 30, 1898, says that he has received a number of communications inquiring into the progress of street paving in that city, and desires to state that the area of carriage pavements is 6,500,405 square yards. Of this area, a fraction less than 74 per cent. has stone pavement, about 25 per cent. asphalt, and a fraction over 1 per cent. wood pavement. The proportion of asphalt is steadily increasing. The soil, continues Mr. Goldschmidt, consists of coarse, gritty sand, forming apparently an excellent foundation for the heavy 8-inch layer of gravel and cement, over which the 2-inch covering of asphalt is spread, making a strong and durable pavement. The average price of asphalt pavement in Berlin is $2.80 per square yard. The city government grants the contracts for laying the pavements, and also for keeping them in repair for twenty years, the first five years without extra compensation and after that for an annual compensation of ten cents per yard.

The results of some experiments for determining the conditions under which boilers burst were lately communicated by M. Hirsch to the French Société d'Encouragement pour l'Industrie Nationale. For measuring the temperature of a boiler plate, with various intensities of firing and under different circumstances, a plate 10 mm.—$\frac{4}{10}$ in.—thick received a layer of water inside, while the outside was subjected to the action of a blow-pipe flame, the quantity of heat traversing the plate being measured by the volume of cold water vaporized, and the outside temperature of the plate by metal plugs fusible at various temperatures. The experiments showed that, when the plate is sound, clean, and thoroughly wetted by the water, it never attains a dangerous temperature, even with the hardest firing, and that viscosity of the water exerts but little influence; but, on the other hand, the deposit of scale, even in a very thin layer, may lead to serious accidents. Some fatty matters coating the inside surface of the plate readily cause it to become red hot, even when in contact with water, which in that case assumes the spheroidal state, this being the case with organic fatty matters, especially linseed oil and red lead cement.

When scientists are at a loss for a new line of research to take up, they can always fall back on the mechanical equivalent of heat, and devise a new method for its determination. The latest workers in this field appear to be MM. J. B. Baille and C. Féry (Comptes Rendus, May 23, 1898), who make use of the tendency of a copper cylinder to rotate in a rotary magnetic field. The cylinder is prevented from moving, the couple tending to rotate it is measured by a balance, and the heat generated is measured by noting on a thermometer the rise of temperature in a given time, a correction being made for cooling. A two-phase current was used, whose frequency was measured by a speed-counter on the dynamo, and this current passed through a ring coaxial with the cylinder. The cooling correction was large, and it is suspected was a cause of inaccuracy, and the experiments are to be repeated with a modified apparatus. To give an idea of the magnitudes measured, we cite the first and last readings of the series: Time, 5 minutes; moment of couple, $1 \times 3{\cdot}270$ grammes; rise in temperature, 1·74° C.; correction for cooling, 1·07° C.; "true" rise in temperature, 2·81° C.; E = 425. Time, 25 minutes; moment of couple, $1 \times 3{\cdot}211$ grammes; rise in temperature, 0·93° C.; correction for cooling, 1·83° C.; "true" rise in temperature, 2·75° C.; E = 426.

Some remarkable experiments were lately made with a train of fifty coke wagons, all fitted with the rapid-action Westinghouse brake and a new friction apparatus, each wagon being loaded with about twenty tons of coke, says The London Engineer. The running of the train was as easy as that of a passenger train, and a favorable occasion was afforded for watching the effect of shock on the new apparatus. At a certain point in the line the wagons had to be weighed separately, an operation that occupied less than twelve minutes, being performed in the following manner: The engine was uncoupled from the train and run forward a distance of 20 meters (22 yards), and a second engine, brought up to the rear of the train, then pushed the wagons, which were uncoupled by two men, in such a manner as to pass one by one over the weighbridge. While each wagon ran over this weighbridge, of rather considerable length, the weight was taken and booked, after which it ran on until it butted against the engine at a speed of 5 to 8 kiloms. (3 to 5 miles) per hour. It was, therefore, easy to watch the action of the buffers, the stroke of which in most cases was not quite completed; and this circumstance shows that the friction apparatus was fully capable of taking up the vis viva of the wagon and its load. This train was followed by another, just the same except that it was not fitted with the friction apparatus, so that the difference could easily be observed. In the latter case the whole structure of the wagons was severely shaken, so that it was manifest the friction apparatus is calculated to greatly prolong the life of rolling stock. These observations were made to the Liége Engineers' Association by M. R. Kapteyn, manager of the Westinghouse Company, in his communication on continuous brakes, the absence of which from goods and mineral trains forms a constant danger to passenger trains.

ELECTRICAL NOTES.

The bill for the legislation of the ohm, volt and ampere in Germany has now passed through all its stages in the Reichstag. It is satisfactory to note that it has been amended to the extent of an "e," added to the atrocious word "amper," originally proposed.

The number of telephone subscribers in the world is about 1,400,000, of which 900,000 are in the United States, 12,000 in Spain, 140,000 in Germany, 75,000 in Great Britain, 50,000 in Switzerland, 35,000 in France, 20,000 in Austria, 18,000 in Russia, and 2,500 in Cuba.—La Nature.

Manager Naylor, of the electric light plant in Wadena, Minn., has placed red and blue electric lamps on top of the water tank to give notice of the way battles have gone in the war. If Spain is winner, the red lamps will be turned on; if the United States is on top, the blue will announce the glad news.

An electric power station of 25,000 horse power will be constructed at Assouan on the Nile (Egypt), and power will be transmitted to a distance up to 100 miles. The pyramids will be lighted electrically; electrically worked pumps will be used for irrigation purposes, and spinning mills will probably be erected where the new power will be available. The Westinghouse Electric and Manufacturing Company has secured the contract for this great undertaking.—L'Electricien.

Th. Schlumberger has discovered that nitrated cotton is readily soluble in dilute alcoholic solutions of various salts, such as the chlorides of ammonium, calcium, magnesium, aluminum, and zinc, and the acetates of soda, ammonia, and potash. The new solvents considerably decrease, and in certain cases entirely remove the danger of inflammation and explosion. The collodion thus obtained is therefore much easier and safer to handle than ordinary collodion.—L'Electricien.

The Baltimore and Ohio Southwestern Railway officials have solved the problem of cooling sleeping cars in stations at night. At Cincinnati, Louisville and St. Louis this line has sleeping cars placed in the stations at 10 P. M. which do not depart until after midnight, and in order to make them comfortable and cool have placed 16-inch rotary electric fans in each end of the sleepers, thus removing the heated and impure air from all parts of the car. The fans have been in operation about two weeks and have been the subject of many favorable comments from the traveling public.

R. Abegg endeavors to clear up the large discrepancy between the dielectric constants of ices of slightly different constitution, as found by Dewar and Fleming. The extreme figures are 103 and 3·6 at −50° C. None of these are probably reproducible, since the "constant" depends largely upon the configuration of the conducting channels which almost necessarily remain in the body of the ice. The effect of these canals would be different for different electrical vibrations, and this would account for the different results obtained by Nernst's method. The author abandons as untenable his previous suggestion that the high values were attributable to an electrolytic polarization of the condenser plates, but insists that no definite conclusions can be drawn from the English experiments until all accidental causes are eliminated.—Abegg, Wied. Ann., No. 5, 1898.

Much attention has been paid to the production of ozone for bleaching purposes. The Fahrig process was a chemical one. It was first produced chemically, and then passed through the electric discharge of a condenser attached to a transformer having a calculated electromotive force in the secondary winding of 40,000 volts. The ozone was produced by the action of the electric discharge in the oxygen, and it was piped from the ozonizing generators to suitable receptacles. M. Andrioli has devoted much attention to the matter, and he is now able to produce 130 grammes of ozone per kilowatt hour. He has a large size of ozoner, consisting of grids formed of serrated wires and flat electrodes. The grids are formed of aluminum and of flat aluminum electrodes. One of these grids has 80 rows of serrated wires, each having 22 points, making a total of 17,760 points on both sides.

Yet another attempt is being made to convert peat into charcoal, says Industries and Iron. This time electricity is being pressed into the service by M. B. Jebsen, who mounts three cylindrical retorts upon trunnions in a frame carried on rollers. The retorts are lined with asbestos or other non-conductor of electricity and heat, which is wound spirally with an iron wire. Another winding is embedded in asbestos surrounding the core. These wires form suitable resistances for developing heat from the electricity traversing the conductors through the terminals, which are connected at the axles. Vents are established by means of stopcocks, through which moisture and gas are permitted to escape. It is claimed that the turf or peat is thus heated uniformly and thoroughly, as well as more exactly than by the method formerly employed, thus saving destructive burning and insuring a saving of time in production.

There is now pending in Congress a measure reported on by the House Committee on Interstate and Foreign Commerce providing for a subsidy of $100,000 per year, for 20 years, to be paid to the company which shall lay a cable between the United States and Hawaii, and from there on to China and Japan, with a cable station at the midway point. The bill mentions the Pacific Cable Company, which now has cables in operation between the United States and Mexican points and along the South American coast, as the intended beneficiary. The line will necessarily have to be nearly 7,000 miles long, and it is proposed that it shall be completed by the beginning of the year 1900. In consideration of the subsidy, government messages are to be transmitted free of charge. Maximum rates to be paid by the general public are fixed by the bill. An attempt is being made to introduce the Corliss substitute for this bill, which provides that advertisements shall be circulated calling for bids to lay the cable for the least subsidy. It is stated that the effect of earthquake shocks, which occur more frequently in the Pacific than in the Atlantic, has been an important consideration with those who have made a study of the conditions which might affect the operation of a Pacific cable.

MISCELLANEOUS NOTES.

Wise-Eddy kites, carrying photographic apparatus, are being prepared for use in Cuban land operations. They will be used for taking photographs of the enemy's position and for making signals to distant points. The corps organized is under the command of Lieut. Hugh D. White, of the Ninth Infantry, U. S. A. Flags in the daytime and electric light at night will be employed in signaling.

In "rawhiding" ore in British Columbia, cowhides are used just as taken from the carcass; inch holes are cut one foot apart around the edges, the hide laid flat, and the ore piled in sacks thereon; the ends and sides are drawn together by a rope passed through the holes, the neck in front, and fastened to a singletree. A mule is the motive power, says The Mining and Scientific Press, and fast time is made down the trail, a rough lock, consisting of a log chain, being used in steep places.

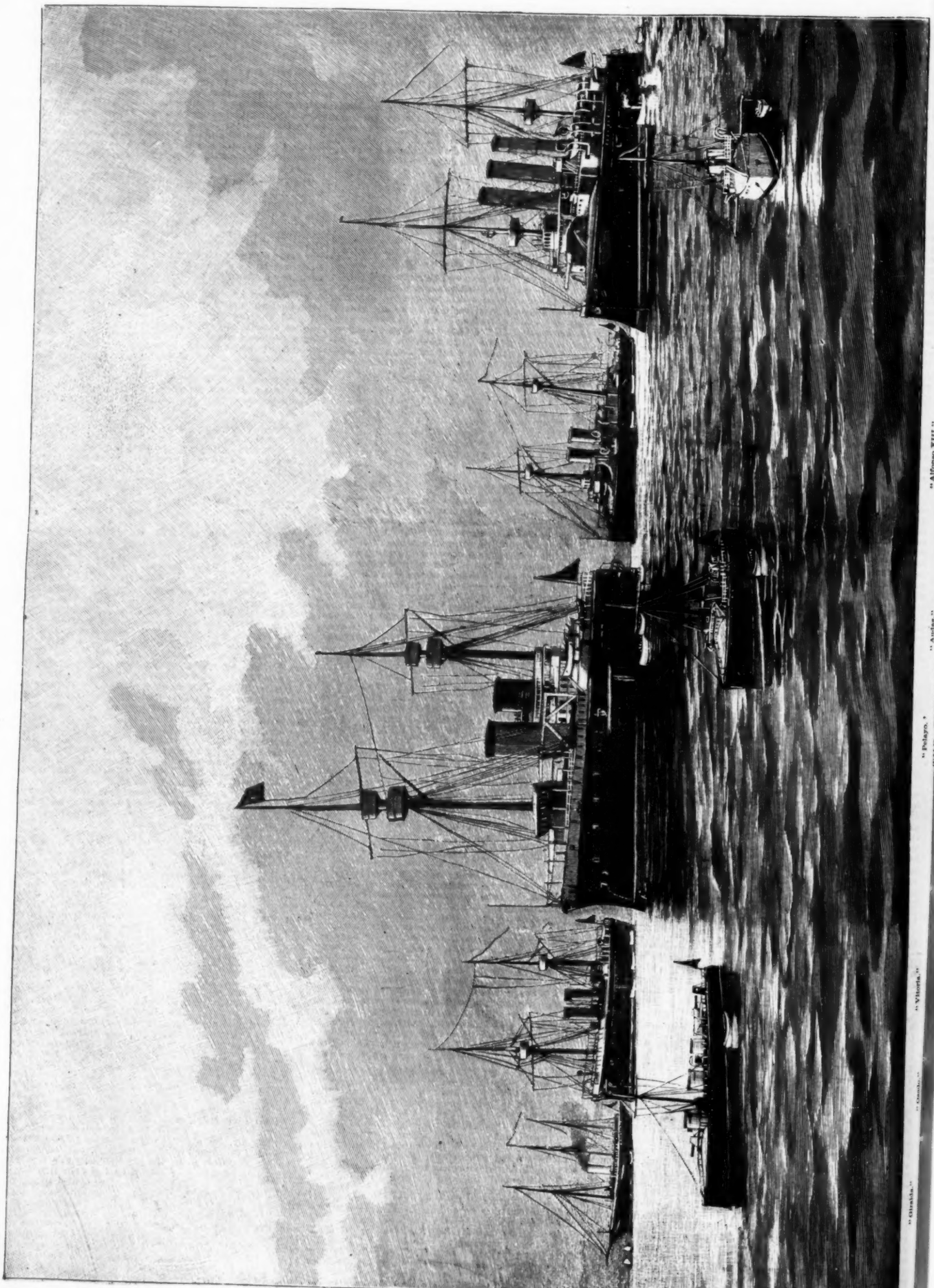
The Federation Colombophile de Marseilles (France), which has for five years been training homing pigeons for the purpose of securing information from ships at sea, now furnishes reports of the complete success of the experiments. Birds released from Marseilles steamers at a distance of 312 miles from that port have reached the home lofts promptly. Similar experiments are being made on the Atlantic liners, and it is not too much to expect that in the near future there will be less uncertainty concerning the fate of belated steamers.

Vienna has been astonished lately by some daring steeple climbing. A steeple jack celebrated the beginning of the festivities for Emperor Francis Joseph's jubilee by climbing in the night to the top of one of the steeples of the Votive Church, 306 feet from the ground, by means of the lightning rods and architectural ornaments, and hanging on it a yellow and black banner twenty feet long. He gave a minute description of the manner in which he accomplished his foolhardy feat to the newspapers. A few nights later some one else imitated him by climbing the steeple and stealing the flag.

"Several years ago," says The American Manufacturer, "when the supply of natural gas showed such a decided drop, it was predicted that the new fuel would before long be a thing of the past. The latest report of the Philadelphia company, which has been the most extensive operator in natural gas, indicates that the supply is holding out unexpectedly well. This report is the thirteenth annual statement made by this company, and shows that during the past year it drilled 51 wells, 31 being productive of gas, 11 of oil, and 10 dry. The company is now operating 924·41 miles of pipe, has 68 telephone stations and 380·3 miles of telephone wire. The amount of natural gas sold during the past year was 10,857,956,000 cubic feet, all of which was sold by meter."

"The export trade of this country in paraffin and paraffin wax has grown up very rapidly," says The New York Times. "Twenty-five years ago this material was unknown to commerce, and only fifteen years ago it began to be exported. In 1884 the exports of the product were more that 17,000,000 pounds, of which 16,000,000 pounds went to Great Britain. In the fiscal year 1897 the American exports of paraffin and paraffin wax reached about 126,000,000 pounds, of which the United Kingdom took 82,000,000. In this country the consumption of this article has increased at a still more rapid rate, but the production has more than kept pace with the demand. The marked chemical indifference of the substance has led to its introduction in connection with a large number of industries. It is employed for lining wooden and metal vessels for acids, and voltaic batteries, in electric insulation, in coating splints and other appliances subject to septic influences, as a vehicle for fulminate in the manufacture of matches, as a covering for cartridges, for preserving fruits and vegetables by forming a coating over their surface, and for an almost endless variety of similar purposes."

In the statues in the tower of the Philadelphia Public Building the bronze base-plate supporting the statue rests directly upon the cover-plate of the apex-cap; it is 9 feet in diameter and $6\frac{3}{8}$ inches high, cast in halves, and formed of radial and annular ribs, 1 inch thick, cast on the upper plate, which is $1\frac{1}{4}$ inches thick; the halves are bolted together through two ribs that form the joint, and the whole is bolted to the apex-cap by eight $1\frac{1}{4}$-inch square steel eye-bolts with $2\frac{1}{4}$-inch diameter nuts; these eye-bolts are held by the steel pins in the brackets of the apex-cap and placed in a circle. Two of these bolts enter the feet of the statue. Besides the eye-bolts, each foot is bolted to the base-plate by four 2-inch diameter bolts, two of steel and two of bronze. The tree-stump, forming a part of the statue, is bolted to the base-plate by thirty-six 1-inch diameter bronze bolts, while the parts that form the figure are bolted together through flanges, as also to the stump, thus forming one united mass—the connection between stump and figure being at the left hand, skirt of coat, and thigh of body to the upper portion of the stump with bolts. The thickness of the metal of statue varies from $\frac{1}{4}$ of an inch in upper parts to $\frac{3}{4}$ of an inch at the ankles and $1\frac{1}{4}$ inches for the soles of the feet. The stump averages $\frac{3}{8}$ of an inch in thickness, and all flanges for joining the parts were $\frac{5}{8}$ of an inch thick and about 3 inches wide. The base-plate is provided with two manholes—one to the outside and the other to the interior of the stump. These are furnished with watertight manhole covers. Another manhole is in the crown of Penn's hat, the cover-plate of which is glazed to light the interior of the figure. No internal braces were found necessary in any of the statues. The four groups of 24-foot high statues at the base of the pyramid (a Swedish man and boy, a Swedish woman, girl and lamb, an Indian chief and dog, and an Indian woman and boy) are supported on cast-iron base-plates bolted to the upper members of the framework below. The plates are covered by $\frac{3}{8}$-inch thick bronze plate, upon which the statues rest, being bolted to the cast-iron base-plate through the feet and other available members of the statues. The alloys composing the statues were: For William Penn and the Indian chief, 90 parts copper, 10 of tin. All other statues were 88 parts copper, 20 of tin, and 2 of zinc.


"Emperador Carlos V."
"Alfonso XIII."
"Pelayo."
"Numancia."
"Vitoria."
"Gravina."

THE SPANISH RESERVE FLEET OF ADMIRAL CAMARA.

ACCORDING to official reports, the Spanish reserve fleet under the command of Admiral Cámara left Cadiz on the 28th of May, bound no one knew whither. Since then the fleet has been sailing in a strange, purposeless way in the Mediterranean Sea, and finally entered the Suez Canal, apparently with the object of making for the Philippines. The Spanish government, it now seems, has abandoned the project of sending the reserve fleet to Manila, on hearing of the reported mobilization of an American fleet which was to visit the Spanish coasts. The reserve fleet, it is said, was first to practice squadron evolutions and was then to await further orders. This report may possibly have been circulated by the Spanish government for the purpose of deceiving the enemy as to its real intentions.

Of Admiral Cámara's fleet, the battleship "Pelayo" is the most formidable vessel. She was launched in 1886, at La Seyne, near Toulon, France, and was reconstructed last year. She is a 9,900-ton ship of 16 knots speed, carrying two 12½ and two 11-inch guns in 11-inch steel barbettes placed high above the surface of the water. She has a 17·7-inch belt of steel along the whole water line. Her secondary battery contains nine 5½-inch rapid-fire guns. She was fully described in last week's SUPPLEMENT.

Next to the "Pelayo" in strength comes the "Carlos V.," a fast armored cruiser of 9,235 tons and 20 knots speed. The secondary battery of the "Carlos V." is protected by a continuous belt of 2 inch steel and her curved deck plating is 6½ inches thick. She carries two 11-inch guns disposed in two barbettes of 10-inch steel, and her secondary battery is composed of eight 5½-inch and four 3·9-inch rapid-fire guns.

The "Vitoria," the third vessel in Admiral Cámara's fleet, is a reconstructed old broadside battleship of 7,250 tons built in 1865. She is 318 feet long, has an extreme beam of 56 feet and a draught of 25 feet. Her speed is 11 knots. It is said that she has recently been provided with a rapid-fire battery of 5½-inch guns and with military masts.

Besides these vessels, there is the protected cruiser "Alfonso XIII.," a 5,000-ton ship mounting four 7·8-inch Hontoria and six 4·7-inch guns. She has also six 2·2-inch rapid-fire and six 1·4-inch guns.

In addition to the vessels already enumerated, there are also the "Aviso Giralda" and the torpedo boat destroyers "Audaz," "Osado," and "Prosperina." These latter are 30-knot boats, each of 380 tons displacement, 215·20 feet long, and are provided with two tubes for Whitehead torpedoes.

It is said that the two cruisers "Patriota" and "Rápido" have been added to the fleet. The "Rápido" is a 570-ton vessel, 190 feet long, drawing 10·4 feet of water. Her battery consists of two 4·7-inch Hontoria and four 2·2-inch rapid-fire guns. For our engraving we are indebted to Die Illustrirte Zeitung.

THE MAXIM-SCHUPPHAUS SMOKELESS POWDER.

IN ARMY AND COAST DEFENCE SUPPLEMENT we gave an account of the smokeless powder invented by Mr. Hudson Maxim and Mr. Schupphaus. It will be remembered that the distinguishing feature of this powder is that it burns slowly at first, when the projectile is moving gently through the bore of the gun, and that its rate of combustion increases steadily as the speed of the shot augments, the object being to keep a fairly uniform pressure behind the projectile all the time it is in the barrel. This result is attained by forming in the powder longitudinal perforations, of polygonal cross-section, and, in some cases, by delaying the ignition of the outer surface of the powder by coating it with varnish. In illustration of the variation in the rate of combustion of powder grains or masses, due to the area exposed to combustion, Mr. Hudson Maxim and Mr. Fred H. McGlahie have furnished us with the three diagrams on this page. Fig. 1 shows the relative amounts of initial burning surface per unit of weight presented by various grains. The upper line represents cubes, spheres, and solid cylinders one diameter long; the second line represents long solid cylinders, like cordite; the third, multi-perforated grains three diameters long; and the fourth, coated torpedo powder of the same kind. Evidently the last two present a relatively small area for combustion at first.

When the diameter of a cube has by combustion been reduced 0·2 of its burning thickness or least dimension, 0·45 of the entire cube has been converted into gas. When, by combustion, the diameter has been reduced 0·5 of its least dimension, 0·875 of the entire weight has been converted into gas. This transformation of seven-eighths of the charge into gas when the grain is only burned half through is hardly an ideal way of obtaining high ballistics, especially when the grains are made of such thickness as to be wholly consumed by the time the projectile leaves the gun. The flat, laminated, or tubular forms of grains employed in smokeless powders, although an improvement upon the cube, are still unsatisfactory. With the reduction of the least dimension by two-tenths, there has been transformed into gas 0·22 of the charge, and by the combustion of 0·5 the gas figure is 0·53 of the charge, but still such powder is consumed with a rapidly decreasing burning area.

With the multi-perforated grains of the Maxim-Schupphaus powder a different result is obtained. With the seven-hole segmental grain, when 0·2 of the burning thickness is consumed, only 0·17 of the grain is burned, and upon the consumption through a thickness of 0·5 of the least dimension, but 0·45 of the same is consumed. With the 19-hole segmental grain, when 0·2 is burned, a combustion has taken place of only 0·15 of the entire thickness of the grain, and when 0·5 of the thickness is burned, but 0·42 of the weight of the charge is consumed, and the powder gas is evolved with a constantly increasing rate.

Fig. 2 graphically represents the relation between the proportion of the least dimension burned and the corresponding portion of the weight of the grain burned. The dotted line represents the combustion of a grain with a constant rate of evolution of gases. The curves above show grains with decreasing rates, and the curves below grains with increasing rates. Only the Maxim-Schupphaus powder gives the lower curves.

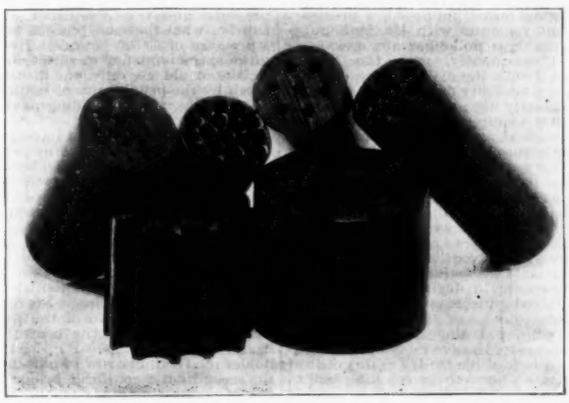
Fig. 3 combines the data of Figs. 1 and 2, and illustrates in a still better way the peculiarities of the multi-perforated grains. This figure represents the relative amounts of burning surfaces at different stages in the combustion, such as would be presented by equal charges of a powder made up into the various forms of grains, all having the same burning thickness.

Fig. 4 shows at A a cross section of an original Maxim-Schupphaus grain with seven perforations, and B shows the same grain when the perforations have burnt out so that they become tangent. With such a grain the maximum ballistics are attained when it is made so that the perforations become tangent at the instant before the projectile leaves the gun. But with such a grain 15 per cent. remains unburned; consequently, it is necessary that the perforations become tangent and the maximum increase of burning surface attained just before the projectile reaches the muzzle of the gun. In other words, the powder is made quicker.

A material advantage is secured by making the grain larger and perforating with a larger number of holes, preferably 19, as shown in C, Fig. 4. D shows C burned out until the perforations become tangent. Obviously the larger the number of perforations, the higher the ballistic value of cylindrical grains, when the same are made without exterior protection.

Colloidal smokeless powders are burned only by surface combustion, so that the grain may be made with equal burning thicknesses in all directions between angular perforations having parallel surfaces, whereby the entire grain is caused to be completely consumed at the instant of interjunction of the perforations with one another.

E, Fig. 4, shows an end view of a 7-hole grain having angular perforations, and F shows the same grain burned out to a point an instant before the interjunction of the perforations. G is an end view of a 19-hole grain with angular perforations, and H shows the same grain burned out to a point an instant before the interjunction of the perforations. I is an end view of a 19-hole grain of torpedo powder with angular perforations, with an exterior covering or coating of non-explosive material, and J shows the same grain an instant before complete consumption. It will be observed that there is no exterior combustion, except of the coating, the coating being made of a thickness determined by experiment, so that it shall be burned through at the instant the rest of the grain becomes entirely consumed. K is a side view of a grain of coated torpedo powder, the same as is shown in cross section in Figs. I and J.

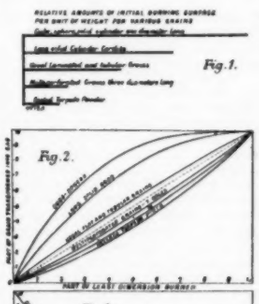


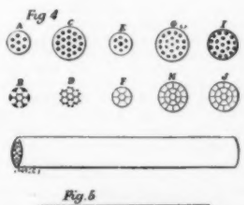
MAXIM-SCHUPPHAUS POWDER BEFORE AND AFTER FIRING.

The Maxim-Schupphaus powder compound is also a very important part of the system. It is especially adapted to the production of multi-perforated grains. The inventors state that after extended investigation they have discovered a new property of nitro-cellulose by virtue of which their powder compound conforms exactly to the shape of the die, and retains that form without warping or cracking in drying. This formula may be varied with respect to quantity of nitro-glycerine within wide limits, either leaving it out altogether or employing any percentage that may be desired, so that the powder compound, or process and composition, may be adapted to fit the ideas of powder experts who have different opinions concerning the advantages and disadvantages of varying percentage of nitro-glycerine.

In an Armstrong 12-centimeter rapid-firing gun, Maxim-Schupphaus powder gave a velocity of 2,037 feet per second to a 55-pound projectile, on a pressure of 33,500 pounds. Cordite supplied with the gun from England gave a velocity of 2,079 feet per second, on a pressure of 40,000 pounds, only 42 feet more velocity with 6,200 pounds greater pressure.

The above results were obtained with a compound containing only 10 per cent. of nitro-glycerine, but notwithstanding this fact, higher velocities for less pressures have been uniformly attained with the Maxim-Schupphaus powder than with any high percentage nitro-glycerine powder that has been fired against it. Of course, still higher results may be obtained with the Maxim-Schupphaus powder by adding a larger percentage of nitro-glycerine to the compound. It is





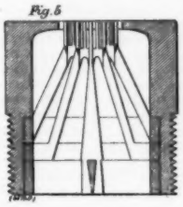


FIG. 10.

FIG. 6.

FIG. 7.

FIG. 8.

FIG. 9.

well known, however, that large percentages of nitroglycerine enhance the erosive action of powder gases upon the gun, and that low percentage compounds like the Maxim-Schupphaus, under equal pressures, have much less such action.

The chief amount of erosion is produced while the projectile is moving along the first few feet of its travel in the gun, due to the greater heat and density of the gases under the excessive pressures necessary to produce high velocities with usual forms of powder grain. When the pressure has, however, fallen to a point where it equals the maximum pressure necessary to produce equivalent velocities with Maxim-Schupphaus powder grain, there is no longer any erosion, or practically none. Consequently, with the Maxim-Schupphaus powder, due to the maintenance of pressure, there is never any necessity of mounting the pressures to a point sufficiently high to erode the gun.

It is not claimed that a simple cylinder of explosive material, having longitudinal circular perforations as an article of manufacture, is new or patentable; but Messrs. Maxim and Schupphaus claim that the process and the tools are new by means of which they produce such a rod or cylinder commercially of the compound or material of which it is essential that the grain should be made. Furthermore, they state that it is impossible to produce multi-perforated rods or grains of powder with the small quantity of solvent employed by them, and which secures the material against excessive shrinking, warping and cracking in drying, except by the employment of the mixed guncotton formula and process patented by them.

Tri-nitrocellulose, employed alone, requires a very large quantity of solvent to dissolve it, or even to render it plastic, and it is impossible to dry grains of it of any considerable size without their cracking all to pieces. It is furthermore very difficult to make such a compound take and retain the shape of the forming die.

Consequently, unless a very large percentage of nitroglycerine is employed, it is impossible to work such a compound successfully into the form of multi-perforated grains for large guns. In order that a powder compound shall take and retain the shape of the die in all its geometrical details, it is essential to employ special tools, special processes, and a special compound, and a compound which will permit of being worked in a much drier state, that is to say, with much less solvent than has heretofore been attempted. By means of their special formula of mixed guncottons compounded together, and by working the powder at a slightly elevated temperature, the gelatine-pyroxylin, acting with a very small quantity of solvent, renders plastic a compound consisting of from 80 to 85 per cent. tri-nitrocellulose, or from 90 to 100 per cent. of the mixed guncottons, as any desired percentage of nitro-glycerine may be used, or that material may be dispensed with altogether.

The following, under the head of "Form of Grain," is quoted from the report of the Chief of Ordnance, United States Army, 1896, page 197:

"In my last annual report, I stated that the colloidal smokeless powders, unlike the charcoal powders, possess the property of burning by parallel surfaces in the gun. This property is a very important one, and enables the powder maker to fully realize the theoretical advantages of a progressive combustion of the charge based on the amount of burning surface, long striven for but never obtained with charcoal powders. An example, showing the effect of the form of grain, occurred in my experience during the year. Working with a fixed composition, I endeavored by varying the thickness of a flat grain, about $\frac{3}{8}$ inch square, to adapt it to the field gun. The best results obtainable were 32,000 pounds pressure for the standard velocity of 1,450 feet per second. I then had the same material made in the form of a seven-perforated cylindrical grain, and got at the first trial 1,450 feet per second with 26,500 pounds pressure. The 'progressiveness' of these forms, as defined in my report in the Report of the Chief of Ordnance for 1896, is about 0·6 and 1·2 respectively.

"From the method of combustion by parallel surfaces and the low velocity of such combustion, it results that at least one of the dimensions of the grain of smokeless powder must be small. If, then, the powder be made in solid grains of a generally cubical or spherical form, they will be so small as to hinder the inflammation of the charge, and so give rise to irregular velocities and abnormal pressures. The most obvious method of obviating this difficulty is to make the powder in the form of rods or strips, which is a very useful form, and very favorable to regular inflammation.

"But, then, this form is less progressive than the multi-perforated cylinder; and by increasing the number of perforations a grain of any desired size may be obtained for any given thickness of the walls between the perforations.

"All things considered, the perforated cylinder or disk proposed by General Rodman many years ago, and recently revived in the Maxim-Schupphaus powder, appears to me to be the most suitable and promising form for the colloidal smokeless powders."

It is obvious that a powder which presents a smaller initial burning area than another, and whose area increases instead of diminishing as combustion progresses, must be subject to enormously less variation in ballistics than a powder which presents the maximum area to the ignition flame and burns with a constantly diminishing area.

The Maxim-Schupphaus smokeless powder, when compared with cordite, pound for pound, offers about one-fourth to one-fifth of the initial combustion area, and when compared with ballistite or cubical powders, it offers, pound for pound, less than one-sixth of the initial combustion area. Therefore, it seems probable, when equal charges are fired under like conditions, the Maxim-Schupphaus powder will give at most not more than between one-fourth and one-fifth the variation in initial pressures that cordite can give. The same holds true for velocities, and the results of firing of this powder substantiate this claim.

In the United States Army 3·2-inch field gun, with a density of loading of 0·8041, the powder chamber being filled completely with the powder, six shots were fired which gave an extreme variation in muzzle velocity of only 6 feet, and an extreme variation in pressures of only 500 pounds, the results being about as nearly identical, in fact, as could be measured with the instruments employed. These results were obtained with a grain having only seven perforations; while a grain having nineteen perforations and the outer surface coated, as in the torpedo powder, whereby the initial combustion area is materially reduced, must give even less variation.

With the externally protected powder proposed by Mr. Hudson Maxim for throwing high explosives from ordnance, with a pressure of 10,000 pounds to the square inch, it appears rational that the variations in pressures and velocities could, at most, be only one-third of what the same powder would give fired under a pressure of 30,000 pounds. Hence, under these conditions, the tendency to variation in pressures and velocities could be only one-fifteenth of the variation given by the usual forms of smokeless powders in high-power guns, thus providing against erratic pressures or velocities.

All the advantages that have ever been claimed for compressed air as a means of propulsion for high explosives appear to be secured by the use of the Maxim-Schupphaus surface-protected powder, while gunpowder has the advantage over compressed air in the enormously increased range attainable by it.

Referring to the illustrations, Fig. 5 is a vertical central sectional elevation of the die employed for making longitudinally multi-perforated grains of powder. This die forms the subject of United States patent No. 598,618 and British patent No. 8,569 of 1895. Figs. 6 to 10 inclusive are reproduced from photographs of the die and of the parts before and after assembling. Fig. 6 is the central pin, mounted on its base ring and bridge. Fig. 7 is the coniform bridge holder for the inner row of pins or mandrels. Fig. 8 is the second outer coniform bridge holder for the outer row of perforating pins or mandrels. Fig. 9 shows Figs. 6, 7, and 8 assembled before insertion into the die casing. Fig. 10 shows the die assembled in the casing complete and ready for use.

It is obvious, by the construction and arrangements of supports for the perforating pins or mandrels, the powder material is allowed to freely flow or circulate between the supports, and to flow over the perforating pins exactly in their longitudinal direction, thus obviating any distortion, and, at the same time, enabling the pins to impart to the powder compound their own exact shape. It is obvious, furthermore, that by this arrangement and form of die, the powder material is supplied to the perforating pins freely from all directions, and in such a manner as to obviate any flow of the powder material in a direction transverse to the longitudinal axis of the perforating pins. This arrangement and form of die permits of the powder material being forced through it in a comparatively dry and hard state, without breaking or distorting the die, even when great pressure is employed to force the same through the die.

The inventors have succeeded in moulding into grains through this die a compound of 90 per cent. mixed guncottons and 10 per cent. nitroglycerine, while the compound contained as little as 15 per cent. of solvent.

In view of the late Maxim-Nordenfelt v. Anderson suit and the British government and the questions involved, it may be perhaps well to mention here that the Maxim-Schupphaus smokeless powder is made under the inventions and patents of Mr. Hudson Maxim and Dr. Robert C. Schupphaus, and these do not resemble the inventions or patents of either Mr. Hiram Maxim or the other parties to the suit in any of the particulars involved in the action.—Engineering.

THE DEADLY MODERN BULLET.

IT has been said that the new army rifle is "humane"—that it punctures clean holes, and is less likely to inflict dangerous injury, says The Boston Transcript. According to the best evidence, however, the fact is very much the other way. The new-style bullet, very long and with a diameter about the same as that of a lead pencil, leaves the gun with a velocity of half a mile a second, with a pressure behind it of forty thousand pounds per square inch. Four miles from the muzzle of the weapon, it is traveling at a rate of one hundred yards a second, and will penetrate the abdomen of a man who happens to be in the way. Owing to its velocity, and to its rotary motion of twenty-four hundred revolutions a second, it develops an explosive energy when it strikes anything at a moderate range, splintering bones into small pieces and effectually destroying any organ like the liver or kidney.

Owing to these conditions, a man who is hit in an arm bone or leg bone by a bullet from a modern rifle must in nearly every instance die or submit to amputation. A hole through an important blood vessel, being punched cleanly out, results in profuse and dangerous hemorrhage right away, so that the victim is likely to die before surgical aid can arrive. Much valuable information in this line has been obtained by firing experimentally at corpses at various ranges, and observing the character of the injuries inflicted. It has been found in this manner, incidentally, that one of these bullets will pass through seven men stood in line. The French have done a good deal of experimenting with silhouette soldiers, cut out of boards and fired at from given distances. From the resulting hits they have tried to reckon casualty percentages.

Under modern conditions troops within firing distance of an enemy will have to meet a veritable hail of bullets. A modern rifle is able to deliver forty shots a minute. Herr Prinz, a German military surgeon, writing of the recent civil war in Chile, says: "The Balmacedists, who were no cowards, declared that their astonishment, caused by the terrible storm of projectiles, left them unable to use their own weapons." In a battle the rifles described will be supplemented by improved Gatling guns, which fire one thousand shots a minute, with a muzzle velocity of a quarter of a mile a second, and an effective range of one and a half miles. Under such circumstances, obviously, it will not be possible for military commanders to risk their troops in the open, inasmuch as to do so would be wholesale suicide.

To illustrate the destructiveness of modern weapons on land, let it be supposed that a command is well posted and concealed with a six-gun battery of these small breech-loading cannon, a couple of Gatlings, and a regiment of seven hundred infantry armed with Krag-Jorgensen rifles. A hostile force of twice the strength approaches to within a distance of three thousand yards. The range being carefully calculated, allowing for the expansion of the cones of fire from the artillery the six cannon will cover a line of 1,440 yards. At the word firing begins, and in one minute thirty-six shrapnel are hurled at the advancing foe. They burst two hundred yards in front of the enemy, scattering 10,800 messengers of death among them. In the same minute the two Gatlings deliver two thousand shots, and the seven thousand rifles discharge 14,000 projectiles. In sixty seconds the space occupied by 1,500 men has been swept by a tremendous storm of 26,800 missiles, and two-thirds of the oncoming soldiers are laid low. One more minute, with another such discharge, and few survivors are left to tell the tale of the disaster.

The wounded in a modern land battle will have small chance of rescue. It will not be possible to remove them from the fighting line during the conflict, because the hospital bearers attempting the task would be killed. The best that can be hoped is to attend to them within the next twenty-four hours. The stern facts having been realized, instruction has been given to every private in the United States Army in the art of taking care of himself in case he is hurt. He carries at his belt what is called a "first-aid packet," containing a roll of bandages, an antiseptic compress, and antiseptic gauze, inclosed in a sealed rubber casing. If he suffers from a bullet wound, he stuffs a plug of the gauze into the hole and applies a bandage. This may save his life and give the surgeon a chance when there is an opportunity for treatment.

ON THE STABILITY OF THE SOLAR SYSTEM.*

ALL persons who interest themselves in the progress of celestial mechanics, but can only follow it in a general way, must feel surprised at the number of times demonstrations of the stability of the solar system have been made.

Lagrange was the first to establish it. Poisson then gave a new proof; afterward other demonstrations came, and others will still come. Were the old demonstrations insufficient, or are the new ones unnecessary?

The astonishment of these persons would doubtless be increased if they were told that perhaps some day a mathematician would show by rigorous reasoning that the planetary system is unstable. This may happen, however; there would be nothing contradictory in it, and the old demonstrations would still retain their value.

The demonstrations are really but successive approximations; they do not pretend to strictly confine the elements of the orbits within narrow limits that they may never exceed, but they at least teach us that certain causes, which seemed at first to compel some of these elements to vary fairly rapidly, only produce in reality much slower variations.

The attraction of Jupiter, at an equal distance, is a thousand times smaller than that of the sun; the disturbing force is therefore small; nevertheless, if it always acted in the same direction, it would not fail to produce appreciable effects. But the direction is not constant, and this is the point that Lagrange established. After a small number of years two planets, which act on each other, have occupied all possible positions in their orbits; in these diverse positions their mutual action is directed sometimes one way, sometimes in the opposite way, and that in such a fashion that after a short time there is almost exact compensation. The major axes of the orbits are not absolutely invariable, but their variations are reduced to oscillations of small amplitude about a mean value.

This mean value, it is true, is not rigorously fixed, but the changes which it undergoes are extremely slow, as if the force which produces them was not a thousand times, but a million times smaller than the solar attraction. One may, therefore, neglect these changes, which are of the order of the square of the masses. As to the other elements of the orbits, such as the eccentricities and the inclinations, these may acquire round their mean value wider and slower oscillations, to which, however, limits may easily be assigned.

This is what Lagrange and Laplace pointed out, but Poisson went further. He wished to study the slow changes experienced by the mean values—changes to which I have already referred, and which his predecessors had at first neglected. He showed that these changes reduced themselves again to periodic oscillations round a mean value which is only liable to variations a thousand times slower.

This was a step further, but it was still only an approximation. Since then further advance has been made, but without arriving at a complete definitive and rigorous demonstration. There is a case which seemed to escape the analysis of Lagrange and Poisson. If the two mean movements are commensurable among themselves, at the end of a certain number of revolutions, the two planets and the sun will be found in the same relative situation and the disturbing force will act in the same direction as at first. The compensation to which I have referred will not any more be produced, and it might be feared that the effects of the disturbing forces will end by accumulating and becoming very considerable. More recent works, among others those of Delaunay, Tisserand and Gyldén, have shown that this accumulation does not actually occur. The amplitude of the oscillations is slightly increased, but remains, nevertheless, very small. This particular case, therefore, does not escape the general rule.

The apparent exceptions have not only been dispensed with, but the real reasons of these compensations, which the founders of celestial mechanics had observed, have been better explained. The approximation has been pushed further than was done by Poisson, but it is still only an approximation.

It can be shown in certain particular cases that the elements of the orbit of one planet will return an infinite number of times to very nearly the initial elements, and that is also probably true in the general case; but it does not suffice. It should be shown that these elements will not only regain their original values, but that they will never deviate much from them.

This last demonstration has never been given in a definite manner, and it is even probable that the pro-

* Translation of a paper, by M. H. Poincaré, in the Annuaire du Bureau des Longitudes, 1898, published in Nature.

position is not strictly true. The statement that is true is that the elements can only deviate extremely slowly from their original values, and this after a long interval of time. To go further, and affirm that these elements will remain, not for a very long time, but always, confined within narrow limits, is what we cannot do.

But the problem does not take this form.

The mathematician only considers fictitious bodies, reduced to simple material points, and subject to the exclusive action of their mutual attractions, which rigorously follows Newton's law. How would such a system behave? Would it be stable? This is a problem which is as difficult as it is interesting for an analyst. But it is not one which actually occurs in nature. Real bodies are not material points, and they are subject to other forces than the Newtonian attraction. These complementary forces ought to have the effect of gradually modifying the orbits, even when the fictitious bodies, considered by the mathematician, possess absolute stability.

What we must ask ourselves then is, whether this stability will be more easily destroyed by the simple action of Newtonian attraction or by these complementary forces.

When the approximation shall be pushed so far that we are certain that the very slow variations, which the Newtonian attraction imposes on the orbits of the fictitious bodies, can only be very small during the time that suffices for the complementary forces to destroy the system; when, I say, the approximation shall be pushed as far as that, it will be useless to go further, at least from the point of view of application, and we must consider ourselves satisfied.

But it seems that this point is attained; without quoting figures, I think that the effects of these complementary forces are much greater than those of the terms neglected by the analysts in the most recent demonstrations on stability.

Let us see which are the most important of these complementary forces. The first idea which comes to mind is that Newton's law is, doubtless, not absolutely correct; that the attraction is not rigorously proportional to the inverse square of the distances, but to some other function of them. In this way Prof. Newcomb has recently tried to explain the movement of the perihelion of Mercury. But it is soon seen that this would not influence the stability. It is true, according to a theory of Jacobi, that there would be instability if the attraction were inversely proportionate to the cube of the distance. It is easy by rough reasoning to account for this; with such a law, the attraction would be great for the small distances and extremely feeble for great distances. If, therefore, for any reason, the distance of one of the planets from the central body were to increase, the attraction would diminish rapidly until it would not be capable of retaining the planet in its orbit. But that only takes place with laws very different from that of the square of the distances. All laws, near enough to that of Newton's to be acceptable, are equivalent from the stability point of view.

But there is another reason which opposes the theory that bodies move without ever deviating much from their original orbits. According to the second law of thermodynamics, known by the name of Carnot's principle, there is a continual dissipation of energy, which tends to lose the form of mechanical work and to take the form of heat. There exists a certain function called entropy, which it is unnecessary to define here; entropy, according to this second law, either remains constant or diminishes, but can never increase. When once it has deviated from its original value, which it can only do by diminishing, it can never return again, as it would have to increase. The world consequently could never return to its original state, or to a slightly different state, so soon as its entropy has changed. It is the contrary of stability.

But the entropy diminishes every time that an irreversible phenomenon takes place, such as the friction of two solids, the movement of a viscous liquid, the exchange of heat between two bodies of different temperatures, the heating of a conductor by the passage of a current. If we observe, then, that there is not in reality a reversible phenomenon, that the reversibility is only a limiting case—an ideal case which nature can more or less approach but can never attain—we shall be led to conclude that instability is the law of all natural phenomena.

Are the movements of the heavenly bodies the only ones to escape? One might believe it by seeing that they move in a vacuum, and are thus free from friction. But is the interplanetary vacuum absolute, or do the bodies move in an extremely attenuated medium of which the resistance is extremely feeble, but, nevertheless, is capable of offering resistance?

Astronomers have only been able to explain the movement of Encke's comet by supposing the existence of such a medium. But the resisting medium which would account for the anomalies of this comet, if it exists, is confined to the immediate neighborhood of the sun. This comet would penetrate it; but at the distances at which the planets are, the action of this medium would cease to make itself felt, or would become much more feeble. As an indirect effect, it would accelerate the movements of the planets; losing energy, they would tend to fall on the sun, and by reason of Kepler's third law, the duration of the revolution would diminish at the same time as the distance to the central body. But it is impossible to form an idea of the rapidity with which this effect would be produced, as we have no notion of the density of this hypothetical medium.

Another cause to which I am now going to refer must have, it seems, a more rapid action. It had for some time been imagined, but was first more especially brought to light by Delaunay, and afterward by G. Darwin.

The tides, which are direct consequences of celestial movements, could only stop if these movements ceased. But the oscillations of the seas are accompanied by friction, and consequently produce heat. This heat can only be borrowed from the energy which produces the tides—that is to say, to the vis viva of the celestial bodies. We can therefore foresee that, for this reason, this vis viva is gradually dissipated, and a little reflection will enable us to understand by what mechanism. The surface of the seas, raised by the tides, presents a kind of wave. If high tide took place at the time of the meridian passage of the moon, this surface would be that of an ellipsoid, the axis of which would pass through the moon. Everything would be symmetrical in relation to this axis, and the attraction of the moon on this wave could neither slow down nor accelerate the terrestrial rotation. This is what would happen if there were no friction; but in consequence of this friction, high tide is late on the moon's meridian passage; symmetry ceases; the attraction of the moon on the wave no longer passes through the center of the earth, and tends to slow down the rotation of our globe.

Delaunay estimated that, for this cause, the length of the sidereal day increases by one second in a hundred thousand years. It is thus he wished to account for the secular acceleration of the moon's motion. The lunation would seem to us to become shorter and shorter, because the unit of time to which we ascribed it, the day, would become longer and longer.

Whatever we may think of the figures given by Delaunay, and the explanation which he proposes for the anomalies of the moon's movement, it is difficult to dispute the effect produced by the tides.

It is just this that may help us to understand a well-known but very surprising fact. It is known that the period of rotation of the moon is exactly equal to that of its revolution; in such a way that if there were seas on this body, they would have no tides—at least, tides due to the attraction of the earth; because for an observer situated at a point on the surface of the moon, the earth would be always at the same height above the horizon. It is also known that Laplace tried to explain this curious coincidence. How can the two velocities be exactly the same? It is exceedingly improbable that this strict equality is due to mere chance. Laplace supposes that the moon has the form of an elongated ellipsoid; this ellipsoid behaves like a pendulum, which would be in equilibrium when the major axis is directed along the line joining the centers of the two bodies.

If the initial velocity of rotation differs slightly from that of revolution, the ellipsoid will oscillate about its position of equilibrium without ever deviating much from it. A pendulum which has received a slight impetus behaves in this way. The mean velocity of rotation is then exactly the same as that of the position of equilibrium round which the major axis oscillates; it is, therefore, the same as that of the straight line which joins the centers of the two bodies. It is therefore strictly equal to the velocity of revolution.

If, on the contrary, the initial velocity differs considerably from the velocity of revolution, the major axis will not oscillate any more round its position of equilibrium, like a pendulum which under a strong impulse describes a complete circle.

It suffices, therefore, that the velocity of revolution should be almost equal to the initial velocity of rotation, in order that it may be exactly equal to the mean velocity of rotation. A strict equality being no longer necessary, the paradox does not exist any more. The explanation is nevertheless incomplete. What is the reason of this approximate equality, of which the probability is no longer zero, it is true, but still very small? And, especially, why does not the moon undergo slight oscillations about its position of equilibrium (if we eliminate, of course, its numerous librations, due to other well-known causes)? These oscillations must originally have existed; they must have become extinct by a kind of friction, and everything tends to make us believe that the mechanism of this friction is that which I have just analyzed with respect to the ocean tides.

When the moon was not yet solid, and formed a fluid in the form of a spheroid, this spheroid must have experienced enormous tides, by reason of the proximity of the earth and of its mass. These tides could only have ceased when the oscillations became almost entirely extinct.

It seems that Jupiter's satellites, and the two planets nearest the sun, Mercury and Venus, have also a rotation, the duration of which is the same as that of their revolution; it is doubtless for the same reason.

It might be thought that this tidal action has no connection with our subject. I have as yet only spoken of rotations, and in the studies relative to the stability of the solar system the movements of translation are only dealt with; but a little attention shows that the same action makes itself equally felt on the latter.

We have just seen that the attraction of the moon on the earth does not act exactly through the center of the earth. The attraction of the earth on the moon, which is equal and exactly opposite, would not pass either through this center; that is to say, through the focus of the lunar orbit. A disturbing force is the result, very small in reality, but sufficient to make the moon increase in energy. The active force of translation thus gained by the moon is evidently smaller than that of rotation, lost by the earth; because a part of the energy must be transformed into heat in consequence of the friction engendered by the tides. The period of revolution of the moon lasting about twenty-eight sidereal days, a very simple calculation shows that this body gains twenty-eight times less vis viva than the earth loses.

I have already explained the action of a resisting medium. I have shown how, by making the planets lose energy, their movements are accelerated; on the contrary, the action of the tides, by increasing the energy of the moon, retards its movements; the month lengthens therefore as well as the day. Now, if this cause acts alone, what is the final state toward which the system will tend? Obviously, this action would only stop when the tides have ceased—that is to say, when the rotation of the earth would have the same duration.

This is not all; in the final state the orbit of the moon must have become circular. If it were otherwise, the variations of the distance of the moon to the earth would suffice to produce tides. As the movement of rotation would not have changed, it would be easy to calculate what angular velocity would be common to the earth and to the moon. One finds that at the limit, the month, like the day, would last about sixty-five of our actual days.

Such would be the final state if there were no resisting medium and if the earth and moon existed alone.

But the sun also produces tides; the attraction of the planets likewise produces them on the sun. The solar system therefore would tend to a condition in which the sun, all the planets and their satellites would move with the same velocity round the same axis, as if they were parts of one solid invariable body.

The final angular velocity would, on the other hand, differ little from the velocity of revolution of Jupiter. This would be the final state of the solar system if there were not a resisting medium; but the action of this medium, if it exists, would not allow such a condition to be assumed, and would end by precipitating all the planets into the sun.

It must not be thought that a solid globe which was not covered by seas would, by the absence of tides, find itself free from actions analogous to those just mentioned, even by admitting that the solidification had reached the center of the globe. This body, which we suppose solid, would not on that account be an invariable one; such bodies only exist in text books on rational "mechanics." It would be elastic and be subject, by the attraction of neighboring celestial bodies, to deformations analogous to tides and of the same order of magnitude.

If the elasticity were perfect, these deformations would occur without loss of work, and without the production of heat. But perfectly elastic bodies do not exist. There would be in consequence development of heat, which would take place at the expense of the energy of rotation and translation of the bodies, and which will produce absolutely the same effects as the heat engendered by the friction of the tides.

This is not all: the earth is magnetic, and very probably the other planets and the sun are the same. The following well known experiment is one which we owe to Foucault; a copper disk rotating in the presence of an electromagnet suffers a great resistance, and becomes heated when the electromagnet is brought into action. A moving conductor in a magnetic field is traversed by induction currents, which heat it; the produced heat can only be derived from the vis viva of the conductor. We can therefore foresee that the electrodynamic actions of the electromagnet on the currents of induction must oppose the movement of the conductor. In this way Foucault's experiment is explained. The celestial bodies must undergo an analogous resistance because they are magnetic and conductors.

The same phenomenon, though much weakened by the distance, will therefore be produced; but the effects being produced always in the same direction, will end by accumulating. They add themselves, besides, to those of the tides, and tend to bring the system to the same final state.

Thus the celestial bodies do not escape Carnot's law, according to which the world tends to a state of final repose. They would not escape it, even if they were separated by an absolute vacuum. Their energy is dissipated; and although this dissipation only takes place extremely slowly, it is sufficiently rapid that one need not consider terms neglected in the actual demonstrations of the stability of the solar system.

UNITED STATES DAILY ATMOSPHERIC SURVEY.*

THE United States Weather Service has been in existence twenty-seven years. During the past twenty-five years the daily synoptic charts of the service have shown the most comprehensive atmospheric survey ever presented to the forecaster or to the broad investigator of the fundamental principles of storms. The vast region now brought under the dominion of twice-daily synchronous observations embraces an area extending 2,000 miles north and south, 3,000 miles east and west, and so fortunately located in the interest of the meteorologist as to cut an important arc from the circumpolar thoroughfare of storms of the Northern Hemisphere. The extreme points of observation are Edmonton, in the Canadian Province of Alberta, on the northwest; St. John's, on the northeast; Key West, on the southeast; and San Diego, on the southwest; and arrangements are now complete for a co-operation with Mexico similar to that in operation with Canada, which will in a few months extend the area of observation southward over Mexico and Yucatan.

It is a wonderful panoramic picture of atmospheric conditions which, by the aid of simultaneous measurements and the electro-magnetic telegraph joining the places of observation by a magic touch, is presented to the trained eye of the forecaster. Each twelve hours the kaleidoscope changes and a new graphic picture of actual conditions is shown. Where else can the meteorologist find such opportunity to study storms and atmospheric changes?

In the middle of the eighteenth century Franklin detected the rotary and progressive motions of storms; early in the nineteenth century Redfield and Espy contended over rival theories as to the mechanical principle involved in the information of storms, and a little later Maury studied the storms of the Atlantic Ocean; still later Loomis, Dove and Ferrel reviewed these theories and added much to our knowledge; but to this late date no one has been able to satisfactorily coordinate the forces operative in cyclones or to assign quantitative values to the horizontal temperature and pressure gradients, to the surface and internal frictions of convection, to centrifugence, to the latent heat of condensation and to the effect of hemispherical circulation. Probably the only component of cyclonic force that is well understood and accurately computed is the deflection due to the earth's rotation.

Our early investigators studied only the storms of low levels and humid airs, where convection was only needed to carry the moist air currents to but a slightly higher elevation before cooling by expansion would produce condensation and an immediate acceleration of the cyclone by the liberation of latent heat. They had never seen the whirling cyclones of the arid northern Rocky Mountain plateau dash down upon our Great Lakes with rapidly increasing energy, notwithstanding the fact that there was little or no condensation, and hence no addition of the latent heat which Espy supposed was absolutely essential to a continuation of storms.

The widely differing elevation, topography, temperature and aridity of the broad region under obser-

* By Willis H. Moore, Chief of Weather Bureau. Read before the Geographical Section of the British Association for the Advancement of Science, Toronto, August 23, 1897, and reprinted from The National Geographic Magazine of October, 1897.

vation give conditions which are unequaled anywhere in the world for the advantages which they present to the physicist to study the mechanical phases of storm development and progression, or at least such as can be profitably studied with observations taken only at the bottom of the great aerial ocean surrounding the earth.

Here we see summer cyclones formed under the intense insolation which beats down through diathermanous atmosphere upon the arid waste of the Rocky Mountain plateau; cyclones which, if they form in the northern part of the Plateau Region, move eastward to our lakes and thence to the St. Lawrence with scant rainfall; cyclones which, if they have their origin farther south on the warmer plains of Colorado, move into the Ohio Valley and thence into New England with considerably more precipitation; and cyclones which, if they have their inception on the hot and high plains of Arizona and New Mexico, can always be expected to give abundant rainfall when they reach the lower Mississippi Valley, and later as they pass over the Middle Atlantic States.

All these can be studied during their inception at an average altitude of 5,000 feet above sea level and under conditions of extreme aridity. They can be viewed later as they come down nearly to sea level in the Mississippi Valley and reach a more humid atmosphere 1,000 miles from the place of their birth; and, finally, they are seen as they reach the extremely humid air of the Atlantic Ocean, 1,500 miles farther east.

The great winter cyclones which originate south of the Japanese islands and cross the Pacific Ocean come under our vision as they successfully surmount the formidable Rocky Mountain barriers with but little diminution of energy, sweep across our continent with increasing force and heavy precipitation, and within three days pass beyond our meteorological horizon at the Atlantic seaboard only to be heard from three days later as borean ravagers of northern Europe.

The great anticyclones or high-pressure eddies, which constitute the American cold waves, drift into our territory from the Canadian Northwest Provinces, and are studied under rapidly changing conditions during 3,000 miles of their course. The high-pressure eddy, with all the convectional principles of the cyclone reversed, may be said not to depend upon the land of its birth for the cold it brings, for a strong vortical and anticyclonic motion at the center is continually drawing down the cold air from above. In the cold wave it must be conceded that the loss of heat by radiation to a cloudless sky is much greater than that gained by compression, or else it must be assumed that the atmosphere possesses such intense cold at the elevation from which the air is drawn that, notwithstanding the heat gained by compression in its descent, it is still far below the normal temperature at the surface of the earth.

The West Indian hurricanes, always at sea level and in humid air, which are the most violent of all American storms, intrude themselves into the domain of the United States weather map at the bend of their parabolic course at about latitude thirty. They have for years furnished a fruitful theme for the thoughts of the investigator.

For twenty-seven years the forecasters of the Weather Bureau have studied the inception, development and progression of these different classes of atmospheric disturbances. From a knowledge personally gained by many years' service as an official forecaster, I do not hesitate to express the opinion that we long since reached the highest degree of accuracy in the making of forecasts possible to be attained with surface readings. It is patent that we are extremely ignorant of the mechanics of the storm, of the operations of those vast yet subtle forces in free air which give inception to the disturbance and which supply the energy necessary to continue the same.

Having long realized this, I determined at once, on coming to the control of the United States Weather Bureau, to systematically attack the problem of upper air exploration, with the hope ultimately of being able to construct a daily synoptic weather chart from simultaneous readings taken in free air at an altitude of not less than one mile above the earth, as it appeared to me that previous plans for investigating the upper air by means of free and uncontrollable balloons, by observers in balloons, or by independent kite stations were of little value in getting the information absolutely necessary to improve our methods of forecasting. Simultaneous observations at a uniformly high level from many kite stations was the plan I inaugurated for the prosecution of this important investigation. Professor Marvin was assigned to the difficult task of devising appliances and making instruments, and I am pleased to say that we have improved on kite flying to such an extent that apparatus is now easily sent up to a height of one mile in only a moderate wind. We have made an automatic instrument that, while weighing less than two pounds, will record temperature, pressure, humidity and wind velocity. Before next spring we expect to have not less than twenty stations placed between the Rocky Mountains and the Atlantic Ocean, taking daily readings at an elevation of one mile or more.

We shall then construct a chart from the high level readings obtained at these twenty stations and study the same in connection with the surface chart made at the same moment. Being thus able to map out not only the vertical gradients of temperature, humidity, pressure and wind velocity, but the horizontal distribution of these forces on two levels, it is hoped to better understand the development of storms and cold waves and eventually improve the forecasts of their future course, extent, and rate of movement.

In exceptional cases we have flown the kites to a height of nearly two miles. From daily readings at only one kite station, at Washington City, we have derived information as to the direction and force of the wind above the 1-mile level, which has greatly assisted us in estimating the future direction of a storm center when our surface chart gave but negative indications. It will be a fascinating study to note the progress of cold waves at this high level and to determine if the changes in temperature do not first begin above. The readings at Washington indicate that contending equatorial and polar winds may be more potent in the formation of storm eddies than heated and ascending convectional currents.

I am anxious to know the difference in temperature between the surface and the upper stratum in the four quadrants of the cyclone and in the four quadrants of the anticyclone, especially when the storm and cold wave conditions are intense. At an elevation of five miles but little effect remains of diurnal temperature variation. At this altitude the atmosphere is free from the disturbing influence of immediate surface radiation, and consequently there is but little change between the temperature of midday and midnight. The vertical distribution of temperature in the several quadrants of the cold wave or rainstorm areas may give a clew to the future direction of the storm. When we are able to construct isobaric gradients at the 1-mile level, it may be discovered that the storm center at that elevation will not always coincide with the geographical location of the storm center at the surface of the earth. The displacement of this center may possibly give some indication of the future direction of the storm. There are many interesting problems to be solved by this investigation.

TELEGRAPHY WITHOUT WIRES.

HERTZ'S experiments, of which we have several times spoken, and which permit of transmitting to a distance electric rays comparable to luminous ones, are now well known. These effects are obtained by means of a Ruhmkorff coil, a special oscillator and a resonator. The oscillator consists, in principle, of two polished metallic spheres put in communication with metallic surfaces forming a capacity. As has been pointed out by Messrs. De la Rive and Sarazin, the production of the waves is considerably increased by causing the spark to appear in an insulating liquid. When the oscillator is in operation, we observe the effects at a distance by means of a discontinuous conductor in the form of a circle that constitutes the resonator. A small induced spark shoots forth between the two extremities of the conductor.

Herein lies the fundamental principle of the production and transmission of the Hertz waves to a distance, in a manner analogous to luminous ones, according to Maxwell's theory, which experiment supports in a striking manner.

We shall not here recall all the experiments made with the Hertz waves, but shall be content to mention only what may prove of use for our subject.

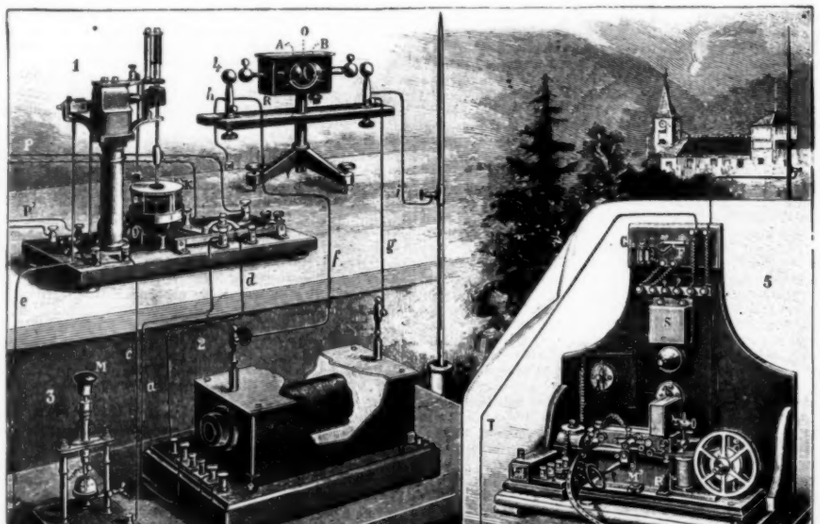
In 1890 M. E. Branley invented the radioconductor, which he has himself described in these pages. This apparatus is a very sensitive revealer of the waves emitted, even at a great distance. It is through the use of such apparatus and of the principles of which we have just spoken that the Russian Professor Popoff in 1895 made his experiments in wireless telegraphy. To this effect, he devised an apparatus for registering the electric waves produced by atmospheric disturbances, and for transmitting to a distance signals registered by a receiver in the Morse code. These experiments were resumed by M. Marconi in 1896.

At the recent exposition of the French Society of Physics, and at the Academy, M. Ducretet took up all these experiments and obtained some truly curious results.

Transmitting Station.—In the accompanying figure we have supposed a transmitting station to the left and a receiving one to the right. The various apparatus are represented as they are arranged for the experiment, and connected by wires. The current sent by a small source of electric energy, P', reaches in the first place the interrupter figured at 1, and the function of which we shall explain. This current serves solely for setting in operation the small motor placed at the upper part of the interrupter. The mercury of the latter is contained in the reservoir, K. Above, there is alcohol protected by a metallic cover. The vertical interrupting rod is actuated by the shaft of the small electric motor and has an alternating rectilinear motion. It was necessary to make such arrangements for the interrupter, because the sparks that leap into the air produce a strong heat that deteriorates the metallic surfaces and prevents the regular operation of the induction coil. A current reaches P from an external source, enters the terminals of the commutator placed upon the support of the interrupter to the right, makes its exit through the wire, a, reaches the second terminal of the coil, traverses the inducing circuit, makes its exit through the next to the last terminal, and, through the wire, b, reaches a manipulator, M, figured at 3. This apparatus consists of a vertical rod that is thrust by hand into an insulating liquid in order that it may bear against a piece of metal and close the circuit. It permits of sending the current into the primary circuit of the induction coil for long and short periods. Upon making its exit from the manipulator, the current ascends the wire, c, to a terminal of the interrupter, traverses a vertical rod and the mercury reservoir, K, and then returns to the commutator and thence goes to the source of the current, P. The two extreme terminals of the interrupter are connected by wires, e and d, with the condenser of the induction coil. The wires, f and g, of the induced circuit of the coil, are connected with the extreme terminals of the oscillator (No. 4). In a reservoir, R, filled with insulating liquid, there are two spheres, A and B, the distance of which may be regulated at will. The spark forms between these two balls, and may be observed at O. One of the wires of an external terminal is connected at h with the ground. The other, at i, ends at a vertical insulated rod carried by an insulating stand.

We have thus all the apparatus necessary for the transmitting station. We in the first place close the circuit of the current, P', by means of a small interrupter placed upon the side, and then set the motor of the interrupter in operation. We afterward close the commutator placed upon the same base, and, by means of the manipulator, M, establish a series of brief or long contacts. Between the spheres, A and B, we thus produce sparks and a series of long or short discharges. The electric waves are transmitted to a distance through space, and will be collected at the

Receiving Station.—At this station, placed to the right of our figure, we find in the first place, at a distance in the background, a vertical rod designed for collecting the electric waves, and similar to the one situated at the transmitting station. At F is the radioconducting tube with an automatic hammer, G, which touches the tube after every reception and puts it in its primitive state. The second wire is grounded at T. These conductors perform the office of collectors of electric waves, and were employed by Prof. Popoff. In the station, there is a very sensitive polarized relay, R, a call bell, S, a Morse registering apparatus, and a second relay, R', for dividing the elements of the local battery that operates the apparatus as soon as the radioconductor is in action. The Morse registering apparatus of M. Ducretet is automatic, and therefore registers, without the aid of a telegrapher, all the electric waves emitted in the atmosphere, or by the receiving station, or any other source. For registering electric and atmospheric waves in observatories, M. Ducretet has arranged a horary apparatus, which runs continuously for eight days.



TRANSMITTING STATION. RECEIVING STATION.

TELEGRAPHY WITHOUT WIRES.

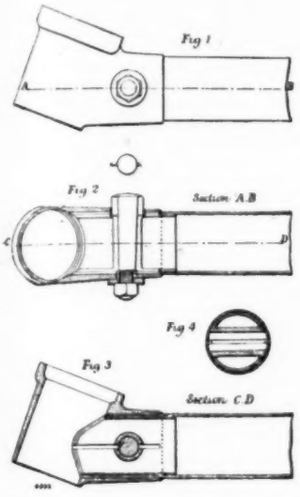
As may be seen, these experiments offer a great interest, and show that M. Ducretet has solved a problem which, a few years ago, one would not have dared to propose.

For the above particulars and the illustrations we are indebted to La Nature.

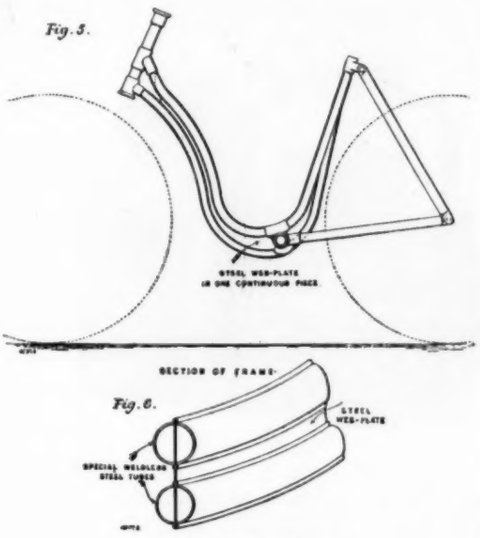
IS RUBBER WATERPROOF?

THE answer to this question is decidedly "No," although many people would not hesitate to reply, "Yes; of course." We speak of unvulcanized rubber. Since the rubber has to be dried to be freed of its moisture, we may a priori conclude that it will absorb moisture again. According to experiments mentioned by E. Schulze in the Gummi Zeitung, it does so with a certain rapidity. Rolled rubber plates, which by virtue of their treatment are in a somewhat compressed condition, absorb from 8 to 35 per cent. of water in two hours, when the water is heated to about 120° F. At increased pressure, the absorption takes place much more readily; a piece of rubber, kept in a cylinder under a pressure of 140 pounds, absorbed 25 per cent. of water in five minutes. Oils, of course, stop the water. Vulcanized rubber remains dry, but not entirely so, and badly vulcanized goods deteriorate quickly owing to this reason. Schulze kept a plate of the best Para

rubber in water at a temperature not exceeding 110° F. After two months and a half the rubber has become a hopeless, smeary mass. We see how badly moisture affects rubber at temperatures such as may occur in our climate, and we understand once more how much the raw material may suffer during transport. The transport may indeed have more to do with the condition and quality of the rubber than the origin. The percentage of water should be ascertained, as the quantity of the sulphur and other ingredients which we admix to the rubber should be settled according to the percentage of dry rubber. It was reported as a curiosity some years ago that a rubber bottle filled with water would gradually become empty. We all know that rubber turns whitish when long in contact with water, but the real significance of the fact is hardly recognized.



THE HUMBER DETACHABLE FRAME JOINT.



BURFORD'S WEB FRAME.

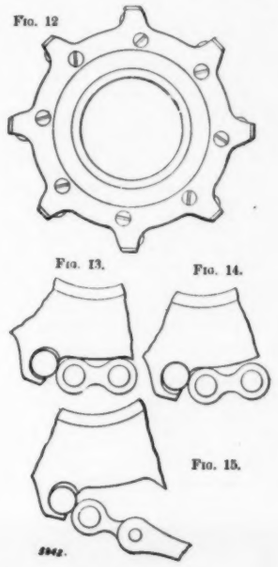
NEW CYCLE DETAILS.

WE illustrate some details of cycle construction that have been introduced and exhibited at the recent cycle shows in England.

Messrs. Humber & Company have introduced a detachable joint, which we illustrate in Figs. 1 to 4, herewith. It is intended to supply a trustworthy mechanical fastening for the various members of a cycle frame, so that brazing will be unnecessary. No doubt the brazed joints in frames are their weak parts, the operation of brazing being by no means certain, especially in careless or unskilled hands. Fig. 1 is an exterior view of a lug with the end of the top bar of the frame in position, Fig. 2 is a sectional plan, Fig. 3 a longitudinal section of Fig. 1, and Fig. 4 a cross section through the lug, tube, and securing pin. It will be seen that the top member of the frame is inserted inside the lug as if it were going to be brazed. Inside the end of the tube is placed a partially split bush, which contains a cross tube also split. Into the cross tube a taper bolt fits, and by screwing up the nut on this, the split end of the tube is expanded, thus gripping the tube and the lug together. It is said that this joint is as secure as brazing at its best. By taking out the taper bolt, the machine can be taken to pieces and packed for traveling or storage in a flat basket; the maximum width and breadth need be hardly more than the diameter of the wheels.

Burford's patent web frame is shown in Figs. 5 and 6. This form of construction is applicable to drop frames for ladies' machines. There are two bent tubes, as shown, and these are connected by a steel web, which extends through the tubes. In order to give rigidity of attachment, each tube is formed with a crease or groove, into which the edges of the web engage and are held. The tubes, naturally, are split where the web comes through, and in order to give increased surface for brazing the metal of the tube is bent down so as to form, on each side, a strip lying in the same plane as the web. This adds considerably to the stiffness of the structure. The web adds very little to the weight, being made of very thin steel, but it gives great additional power to resist deflection. The rigidity of this frame, no doubt, enables a lady's machine to be ridden by gentlemen, and riders of considerable strength and weight may put in a great deal of work without fear of the distortion which takes place with many machines for ladies. A longer wheelbase can also be given with safety, thus affording more room for a lady to mount or dismount. The manufacturers are Messrs. H. G. Burford & Company, of Orleans Works, Twickenham.

Figs. 7 and 8 show a chainless gear which has been brought out by the Quadrant Cycle Company, Limited, of Birmingham. It is known as Lloyd's cross-roller gear, and consists, as will be seen by the engravings, of a pair of gear wheels at the back hub and a connecting shaft, which rotates on ball bearings and runs in a stationary back arm of the cycle. The gear wheels themselves are the novelty in cycle design contained in this arrangement. In place of the ordinary teeth they have pegs (see Fig. 8), which are surrounded by loose collars or sleeves that act as rollers. These rollers are made of hardened and tempered steel, and are said to rotate one-thirty-second with each contact. The advantages claimed for this gear are reduced friction, as compared with the chain, and absence of cross strain. In ascending hills it is said the exertion required is but two-thirds that required on a chain machine. As compared with the ordinary tooth gear, there is said to be an absence of spreading.



Another form of chainless gear is shown in Fig. 9. This is the cam gear, which is being introduced by Mr. T. H. North, of 2 Church Court, Clement's Lane. The cranks are attached to a cam plate, which revolves with them. Traveling in the cam groove or roller path of the plate is a roller, which is attached to a bell-crank lever. This gives a reciprocating movement to a connecting rod, which in turn causes the driving wheel of the machine to rotate. The amount the machine is geared up is regulated by the number of projections on the cam. In the example shown there will be three revolutions of the wheel to one of the pedals.

The outline figures show an antifriction gear wheel, introduced by Mr. J. Rimmington, of Babington Road, Streatham, S. W. Each tooth contains a small hardened steel roller, which is free to roll through a small distance in contact with the end of the chain. The movement of the roller can be followed in the cuts, in which it will be seen how the grinding action, which usually takes place on the teeth of the back pinion, is avoided. This device would seem to require the use of a gear case and a fairly thin oil.

LIQUID AIR FOR BLASTING.

THE most interesting application of liquid air which has hitherto been tried on a commercial scale is to make an explosive by mixing it with carbon. So said Prof. Ewing in the paper he read before the Society of Arts, on March 2. When liquid air, enriched by the evaporation of a large part of its nitrogen, is mixed with powdered charcoal, it forms an explosive comparable in power to dynamite, and which, like dynamite, can be made to go off violently by using a detonator. To make the explosive, the liquid, containing about 40 or 50 per cent. of oxygen, is poured on frag-

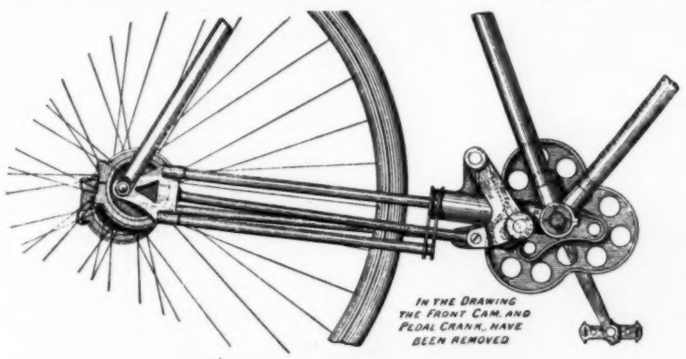


FIG. 9.

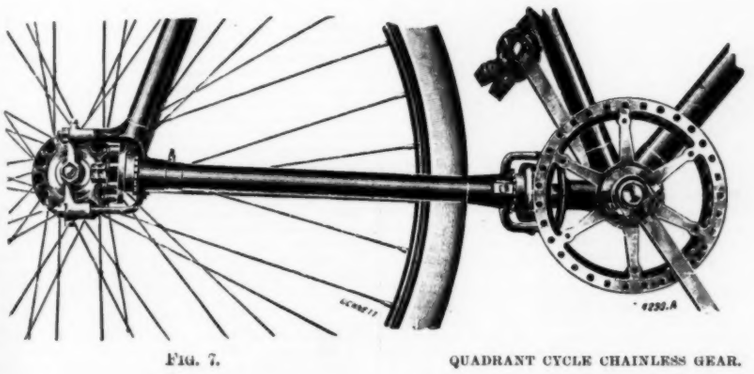


FIG. 7.

QUADRANT CYCLE CHAINLESS GEAR.

FIG. 8.

NEW CYCLE DETAILS.

ments of wood charcoal, 2 to 4 cubic millimeters in size. These are kept from scattering under the ebullition of the liquid by mixing them into a sort of sponge with about one-third of their weight of cotton wool. The liquid which remains is, of course, richer in oxygen than that which is originally applied, and when the mixture is allowed to stand long, all the liquid evaporates and the explosive power disappears. It must, therefore, be mixed at or near the place where it is to be used. But the cotton wadding, impregnated with coarse charcoal powder, can take up more than enough of the liquid to supply oxygen for its complete combustion, and when put quickly into thick insulating cases of paper, it retains its full explosive power for 5 or 10 minutes. After an interval, which ranges from 15 to 30 minutes, according to the size of the cartridge, all explosive power is lost. Experiments were made with this explosive on the parade ground at Munich, and a practical test on a large scale has gone on for some months in a coal mine at Pensburg, not far from Munich. The trials there were continued from July to October of last year, and are claimed to have given very satisfactory results. The chief advantage of the explosive is its cheapness, the cost being simply that of the power used in liquefying the air. Even the fact that after a short time the mixture ceases to be capable of exploding may be urged as a recommendation in one respect, for if a detonator hangs fire, there is no danger of the charge going off accidentally some time after the explosion is due; nor is there any danger of its being purloined or used for criminal purposes. It is questionable, however, if such an unstable explosive can ever be found either convenient or economical, except, perhaps, in large quarries where a large amount of blasting is to be done at one place.

PREPAYMENT METERS.

THE popularity of a prepayment system in connection with artificial illumination is undoubted. It has strengthened the unsecure tenure of the gas companies by creating a handsome revenue from a section of the public which is commonly reputed to be beyond the civilizing influences of quarterly accounts. Light

FIG. 1.

is a necessity even to the submerged tenth, and the essential principles of prepayment were quickly grasped by it.

It was discovered that a pennyworth of gas went further than oil, and was immeasurably more convenient. The fact that it was infinitely safer than the devastating oil lamp may not have counted for much, but no doubt the prepayment gas meter has operated very effectually in this direction. The prepayment system, however, has extended beyond the poorer classes of the community, and it is not uncommon in the flats and domiciles of the well-to-do. With the success achieved by the gas companies so prominently displayed, it was not surprising that attempts should be made to apply the principle to electric lighting, and Mr. C. O. Bastian, whose electrolytic meter has been discussed a good deal of late, has been working on the subject for some two or three years. The prepayment electric meter devised by Mr. Bastian has gone through quite an evolutionary process before arriving at its present form, the chief modifications tending toward a simplification of the instrument.

This prepayment arrangement does not imply a special form of meter, for the device can be attached to any of the well-known types of meter. The illustrations by which we shall strive to explain the working of the instrument show the prepayment mechanism applied to a Thomson watt-meter. The operation of the instrument, by means of a coin, is an interesting and ingenious one. Until a coin is inserted, the handle which projects from the cover is free to move; a coin, when pressed through the slot, falls into a groove and forms a rigid connection between the handle and the interior mechanism, and a turn of the handle switches on the current. The arrangement of the meter will be better appreciated by referring to the detailed parts. Fig. 1 shows the meter and prepayment attachment entirely inclosed, which is the form in which the mechanism will be usually sold. Fig. 2 is front view of the meter, the only features to be noticed here being the coin receiver or shoot shown at O, and the pointers, N N, the exact function of which will be referred to subsequently. Fig. 3 gives a detailed view of the prepayment mechanism seen from the back of the meter. We will now follow the action of the apparatus. Upon the insertion of the coin at B, which makes a mechanical connection, the handle, H, is turned. One result of this is to operate on the pivoted end of the switch, T, which is depressed into the mercury cups, M, thus completing the circuit through the meter. The switch is held in the mercury cups, against the tension of a spring, by means of a clutch, D. The turning of the handle does more than merely put the switch on. In fact, the operation that we are about to describe is probably the most important in the complete action of the mechanism. Above the dials of the meter (Fig. 2)

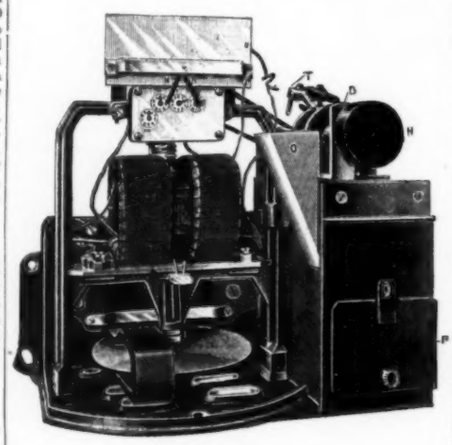


FIG. 2.

will be observed two pointers, and the relation of these to one another is very important. The handle, H, being in connection with a rod, G, its movement will cause a partial revolution of the pulleys, L_1 and L_2. These pulleys are connected together by means of a miniature rawhide belt; pulley, L_1, is mounted on an axle, which carries one of the pointers already alluded to. It will be seen, therefore, that when the handle is turned, one of the needles, through the medium of the pulleys, is moved away from the other pointer, the exact distance of its movement being predetermined. The second pointer is geared to the train wheels of the meter, and when the switch has been put on by the agency of a coin, the meter commences to run, and the second pointer travels slowly after the first one. The exact distance it has to traverse before it overtakes the first pointer is a measure of the current consumed; in fact, the first pointer is caught up by the second pointer in a time inversely proportionate to the amount of current flowing through the meter. The distance that the first is separated from the second is determined by the gear wheels, which are proportioned according to the price per unit and the value of the coin with which the mechanism is intended to be operated.

The more coins that are dropped in, up to a certain limit, the further the first pointer will be separated from the second, and they will be a proportionately longer time in coming together. One side of the first pointer is insulated so that it can come in contact with one side of the second pointer with impunity. The other side, however, carries a platinum contact, and when the second overtakes it and comes in actual contact, a current of electricity at once flows round the electromagnet, E, whose armature is immediately raised, and pulls the clutch, D, away from the switch, F, which immediately flies into the off position.

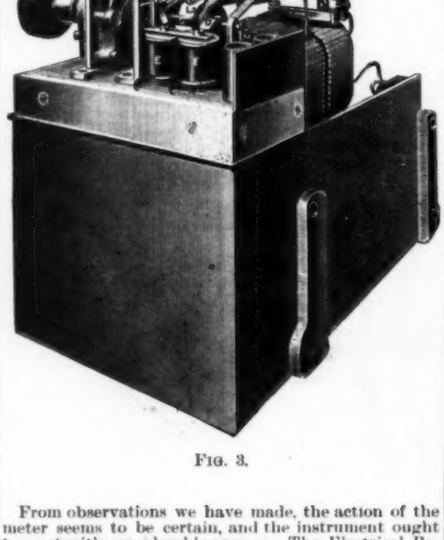


FIG. 3.

From observations we have made, the action of the meter seems to be certain, and the instrument ought to meet with considerable success.—The Electrical Review, of London.

FORTY YEARS OF VITAL STATISTICS IN MASSACHUSETTS.

THE vital statistics of Massachusetts are the most complete of any State in the Union, says The Springfield Republican. They cover a period of great changes in the character and density of the population, and in the employment and life of the people. We may therefore expect to find in a forty years' summary of these statistics, prepared by Dr. Samuel W. Abbott of the State Board of Health, matters of some popular interest and concern.

Let us first bring together the marriage, birth and death rates by five-year periods beginning with and including the year 1856—the rate representing the number of persons married and the number of births and deaths per thousand of population:

	Marriage rate.	Birth rate.	Death rate.
1856–60	19·62	29·51	17·94
1861–65	18·66	25·34	20·71
1866–70	20·96	26·07	18·19
1871–75	19·73	27·62	20·83
1876–80	15·66	24·25	18·84
1881–85	18·54	25·09	19·82
1886–90	18·62	25·86	19·41
1890–95	18·50	25·62	19·83

The marriage rate has noticeably declined during the forty years. It fell off for obvious reasons during the time of the civil war and rose above the average right afterward. In 1866 the rate was as high as twenty-two and fourteen one-hundredths, and it has never during the forty years exceeded that figure. Other considerable fluctuations have been coincident with times of industrial depression and revival and are doubtless to be thus explained. Higher standards of living and the sharpened struggle for an ample livelihood account for the general decline in the marriage rate. People seldom marry at the ages formerly common. Taking the whole number of persons married in the forty years whose ages were known, it appears that in the first twenty years the mean age at marriage for men was twenty-eight and eighty-five one-hundredths, and in the last twenty years twenty-nine, while the mean age for women increased from twenty-four and ninety-two one-hundredths to twenty-five and forty-one one-hundredths.

There has also been a decline in the birth rate during the forty years, and the same causes operating to increase the average age at marriage and to reduce the marriage rate are no doubt accountable for the reduced birth rate. The birth rate among the native born has fallen from nineteen and forty-nine one-hundredths in 1850 to sixteen and fifty-eight one-hundredths in 1895—the period in this comparison being extended to forty-five years. On the other hand, the rate among the foreign born has remained nearly stationary at about fifty per one thousand of foreign born population, or much more than double the native rate. As the foreign born population contains a larger ratio of persons of child-bearing ages than does the native element, the fertility of the foreign is not so great comparatively as the figures indicate, but it is still, nevertheless, far greater than that of the native. And this calls attention to the rather momentous fact that the native born population of Massachusetts to-day is not self-sustaining. A population with only two and three one-hundredths children to each married couple is not holding its own after allowing for the deaths which occur in the first five years of life. Or compare the native birth rate of sixteen and fifty-eight one-hundredths with the native death rate of nearly twenty, and consider where we would come out in the course of time without the infusion of a foreign element possessed of less regard for or hope of reaching an ample and luxurious livelihood. Another fact of moment in this connection is the great increase in the number of illegitimate births within the State. The statistics are very incomplete in this respect, but Dr. Abbott roughly reaches the conclusion from what is known that the ratio of illegitimate births to one thousand births has risen from below ten during the first decade of the forty years to about twenty at the present time. This would be an expected consequence of the tendency to late marriages; but in view of the large immigration, and the fact that in most countries of Europe the rate of illegitimate births to one thousand births rises as high as seventy-five and even above one hundred, other causes come into the problem.

During the forty years the population of Massachusetts has more than doubled, and nearly two-thirds of the increase has come from immigration. The additions from that source have poured largely into the cities, and in the same time the native element has been drifting urbanward. It has been a period of municipal growth extraordinary beyond comparison, and it is a well established fact that the death rate bears a close relation to population density. Hence it is that in forty years of unquestionable progress in medical science and skill, and in improved sanitation, no perceptible reduction in the death rate has been effected. Improved sanitary conditions have, in a word, very nearly overcome the unfavorable influence of increasing density of population. How far the drift of population into great manufacturing and commercial centers has affected the death rate is particularly observable in the case of infants below one year of age. The death rate here has increased to a considerable extent in the forty years, and it is noticeably high in the manufacturing cities, Fall River heading the list. It has been observed that the infantile death rate bears a direct relation to the ratio of married women employed away from their homes, and hence the higher infant mortality rate in manufacturing places, and one effect of the industrial changes of four decades on the general death rate.

But while the chances of life under one year have been lessened in forty years, those of life from one year up to forty have been increased to a marked extent. The records back to 1865 permit this comparison of death rates per one thousand living persons at specified age periods for the two years, 1865 and 1895:

	5-9	10-14	15-19	20-29	30-39
1865	9·63	5·14	9·63	12·58	11·68
1895	6·23	3·18	5·34	7·08	9·67

On the other hand, for ages above forty there has been some increase in the death rate. Among ten principal causes of death, consumption stands first now as

in 1856, but its ravages have been greatly reduced; while scarlet fever and typhoid fever, which stood high in the list in 1856, have now fallen out entirely from the list of ten chief causes of death. Dr. Abbott notes a coincidence between the decline in typhoid fever mortality and the increase in public water supplies, and he regards it as a case clearly of cause and effect. It is certainly a most interesting and striking table which follows, giving the death rate from typhoid fever per 100,000 of living population and the percentage of population not supplied with public water:

Years.	Typhoid death rate.	Per cent. of population without public water.
1856–65	92·9	75·44
1866–75	38·8	58·94
1876–85	47·4	31·75
1886–95	36·4	13·93

Not less marked than the reduction in the special death rate is the astonishing extent to which the people of the State in forty years have established public water supplies.

It is on the whole a most satisfactory exhibit which is made in the forty years review of these matters of life and death. Excessive immigration, great industrial changes and the breaking away of the native population from its rural moorings have thrown upon the State social and sanitary problems of great weight and moment, but they have been met, and in these more vital issues of life it can be said that a healthful progress has been well maintained.

ACERAS BOLLEANA.

THIS fine terrestrial orchid, which attains a height of about half a meter, Mr. Siehe found in the forests of Juniperus excelsa in the north of the Porta sibirica, 3,100 m. above sea-level. Professor Haussknecht thought at first that it was Aceras affinis, but a comparative examination proved it quite distinct. The plant is very fragrant, the flowers green and rosy red. No spots occur on the labellum. There exists also a very rare variety with quite green flowers; the leaves resemble those of A. hircina. There exists also a rare variety, the flowers of which are quite green. It grows near Gullek, about 1,100 m. above sea-level, in a loamy soil. The illustration shows a flower-spike of half the natural size.

We are indebted to The Gardeners' Chronicle for the particulars.

THE "DICTIONARY OF THE EGYPTIAN LANGUAGE."

SEVENTY-FIVE years have passed since Champollion succeeded in reading the first words of hieroglyphic inscriptions, and to-day we remark with wonder to what an extent this insignificant beginning has developed. One of the great peoples of antiquity has been awakened from its long slumber, as it were, and speaks to us from the past through millenniums.

Infinitely difficult was the task which Champollion and his successors had to perform. Of the meaning of the inscriptions which were to be read, but little could be conjectured. They were written in an unknown, involved script employing more than five hundred characters and yet representing no vowels. They were composed in a language with which we were acquainted only through offshoots thousands of years younger. Nevertheless, these obstacles were surmounted in a few decades. When Champollion died in 1832, he had already progressed to such an extent that he could correctly state the meaning of most inscriptions. In 1851 De Rougé published the first translation of a long text. In the fifties and sixties Chabas and Goodwin taught us the method of reading the italic script of papyri and also gave us an insight into the literature and spiritual life of the Egyptians. And at the same time, through the efforts of Brugsch and Dümichen, the baroque hieroglyphics of the Græco-Roman period were deciphered, after the former had already succeeded in translating the infinitely difficult writing of this later Egyptian epoch.

To this extent the infant science had been developed during the first fifty years, and no one can find fault with the Egyptologists of that day if, justly proud of these results, they believed that they had already reached the goal, if many imagined that Egyptian texts would soon be as intelligible to us as the books of the Greeks or Hebrews.

This triumphant mood, it is true, was followed by a calmer tone, and we saw how much was still necessary fully to understand the Egyptian tongue. Neither the vocabulary nor the grammatical construction of the Egyptian language were sufficiently known to us. Even at the beginning of the seventies, Egyptologists could still be heard seriously asking whether the Egyptian language, on the whole, had ever possessed verbs, or whether it had possibly made use only of substantive formations, so little was then known of the structure of a language from which translations were zealously and successfully made. Reliance was placed exclusively on the practice obtained from reading thousands upon thousands of inscriptions, and where this practice did not answer the purpose, recourse was freely had to guessing. As a matter of fact, the correct meaning of simple texts was readily ascertained; but the result of ignoring grammatical constructions is illustrated by the following example, by no means one of the extreme cases. On the epitaph of a prince, the latter declares to posterity that in the pictures of his tomb he has had all his faithful officers and servants represented, and this thought he thus varies in a manner peculiarly Egyptian: "He causes the names of his officers to grow, and perpetuates them according to their offices; he perpetuates the people who are in his houses, and him whom he has raised over his servants, each office which he has filled (?) and each handicraft, even as it is." This, from the ignorance of grammatic relations, resulted in the following idyllic description: "He made the name of his people sprout, who had performed good deeds, each according to his position, for good people were the inmates of his houses. To him who had advanced himself among his bondmen, all positions and all honor (?) were open, as the custom is."

It has been chiefly the German Egyptologists who since that time have wrought a change in this respect. We have learned the manifold constructions and the stern laws of the Egyptian language, and we survey the development of the tongue through 4,000 years. And if many details are unintelligible to us on account of the imperfect signs of the vowels, and will always remain unintelligible, enough has been already obtained to guide us in the translation of Egyptian texts. The time of "divinatory" translations is passed for science, even though the vast host of *dilettanti* may still cling to this convenient mode of procedure.

But this very progress in grammatical comprehension of the language causes us to feel all the more painfully the other gap in our knowledge, our incomplete comprehension of the vocabulary. Of what use is it if we can correctly separate and correctly analyze sentences so long as, on an average, only eight words out of every ten in an Egyptian text are sufficiently known to us? The two which we lack often enough suffice to rob an entire passage of its meaning. Several examples, in which I shall substitute letters for the unknown words, will show how matters stand in this respect.

In speaking of a king, a song written some two thousand years before our era narrates: "He is an *a*, other men are small. He is *b*, a *c*, which the stream *d* against its *e* of waters. He is *b*, an *f*, which causes men to sleep till *g*."

From the style of hieroglyphic writing, it is seen that *b* must be something abstract; *c* and *e* must have something to do with water; *f* must be a house or something

ACERAS BOLLEANA—COLOR OF FLOWERS ROSY RED AND GREEN.

similar; *g* something like light: *d* is a verb which perhaps signifies "to part." With this as a basis, the following translation has been ventured upon:

"He is a [giant], other men are small. He is [like] a [dam] which the stream [parts] against its [floods] of water. He is [like] a [sleeping-chamber] which causes men to sleep till [dawn]."

That is probably correct as a whole, although the comparison with the dam seems rather suspicious; but translations are not always accomplished so readily as this. When, in a fable in the Berlin collection, King Cheops, famed in story as the builder of the Great Pyramid, "has long sought the *jpt* of the god Thohth" in order to imitate them in his pyramid, there is nothing from which we can divine what these *jpt* may be. And when, moreover, in the medical books, for the disease *a*, recognized by the symptoms *b*, the herb *c* and the portion *d* of the body of the animal *e* are prescribed, and *a*, *b*, *c*, *d* and *e* are unknown to us, as it often happens, then there is no possible way of determining the meaning, and the entire recipe remains scientifically worthless.

There are, of course, texts which are composed in ordinary language, but often enough even the meaning of this ordinary construction is known to us only approximately, and at pleasure we translate the same words sometimes by "friend," sometimes by "relation," by "wave" or by "flood," by "sin," "lie," or "injustice"—we only know that the one term refers to a nearly related person, the second to something in water, the third to something evil. In the translation of Egyptian texts, so long as we were content with guessing at the general sense, we were not fully conscious of our lack of knowledge. To-day, when we have abandoned that ingenious mode of procedure, we recognize in this ignorance of vocabulary the greatest impediment offered to our researches; there can, in fact, be no serious advance in Egyptian philology so long as this obstacle has not been removed.

That it is possible to progress even in this respect, and to succeed in interpreting the meaning of most words, no one can doubt who knows the extent of the legacy left by the Egyptians; the matter contained in the papyri, and the inscriptions published up to the present time, is probably three or four times as voluminous as the entire Old Testament, and much is still waiting publication in Egypt and in our museums. We can therefore conclude that words of rare occurrence will be found in this rich material, not only once, but many times, so frequently in fact that by a comparison of their uses, it would be possible for us to ascertain their meaning. Let us, for example, take a verb which is commonly mentioned in connection with the destruction of enemies and which on that account has been translated at pleasure "to kill," "to stab," "to disperse," etc.; a single new passage in which it is said of a remedy that it "disperses" a sickness will suffice to show us that the last meaning alone can be the only correct one. A fatty substance used for an ointment cannot be felicitously translated by "oil" when the word in another passage is spoken of in connection with goose-grease.

Above all, it is therefore necessary to collect on separate sheets all passages in which each Egyptian word occurs; the results will speak for themselves by examining the matter so collected.

But simple as this task may appear, it is proportionately difficult to accomplish, for it is that vast number of texts to which we have already alluded which offers its opposition. If the actual collection is to be fully completed, every sentence must be written once for each word that it contains, i. e., on an average about twenty times; irrespective of all preparatory work, 70,000 hours of labor would be required for this task.

Only as the half-mechanical procedure in collecting, developed by the compilation of the great *Thesaurus Linguæ Latinæ* published by the German academies, became known, was the possibility shown of making a similar collection of all the words found in Egyptian texts. In this method of procedure, each passage is written only once, but with an ink which permits the writing to be reproduced many times by lithographic means. If a sentence is composed of twenty-five words, then twenty-five prints are made on separate sheets of paper, and it is then necessary only to underscore one of the words and to possess a duplicate for each of the twenty-five words. In this manner the labor for the Egyptian language is reduced to one-twentieth of that necessary before, and can therefore be well accomplished.

The collection of the words, it is estimated, will require at least five years and the translation of the matter itself six years; so that in 1909 we hope to begin printing.

The management of this vast undertaking has been assigned to the four German academies of Berlin, Göttingen, Leipsic, and Munich. If, as we hope, we succeed in accomplishing this task, then even before the hundredth anniversary of the deciphering of hieroglyphics has arrived, we shall have brought to its conclusion the work begun by Champollion, and the meaning of Egyptian texts will be revealed so far as this lies within the bounds of possibility.—Translated from the German of Adolf Erman in Cosmopolis.

MINERAL RESOURCES OF THE PHILIPPINE ISLANDS.*

ERE long, doubtless, the Philippines will have to be reckoned with as material factors in the world's gold production, for the precious metal is both abundant and widely distributed throughout the archipelago. Already an English syndicate is engaged in active mining operations on the east coast of Luzon, close to the sea, and the gold formation has been proved to exist over a wide district; further, there is not a stream or brook that finds its way to the Pacific Ocean the sand and gravel of which does not at least yield the "color" of gold. Heavy nuggets are sometimes brought down from the mountains, where there are many promising fields for hydraulic mining. Except on the northern coast, alluvial gold is also had in Mindanao—the largest island in the group next to Luzon, and of an area considerably exceeding that of Ireland. Mindoro is also said to be rich in the metal, traces of old alluvial workings are to be found on Cebu, Panaon has at least one well defined vein of auriferous quartz, and gold exists in greater or less quantities in many other of the islands.

The great drawback to systematic mining everywhere in the Philippines is the lack of practicable roads, and operations necessitating heavy plants are consequently restricted to the vicinity of harbors and navigable streams.

There is no doubt that mining for gold was practiced in these islands long before the advent of the Spaniards, for Doctor von Moëllendorff, an expert sinologist, formerly German consul at Manila, has a Chinese work dating from the third century A. D., in which a trading voyage from Amoy to Luzon is described, and gold is mentioned as the chief product of the island; also names occur therein which are yet recognizable in Manilaian nomenclature.

The tools which the natives use—a washing board and a wooden bowl—are of great antiquity, and notable features of the household belongings of all native villages in the auriferous regions; and in places the ground is fairly riddled with pits that are, or have been, marked in the peculiar slipshod and desultory fashion that obtains to aboriginal exploitation. Bowlders and fragments of quartz with visible gold occur in many alluvial deposits in the islands, and it is not likely they have been thrown aside by the natives without endeavoring to extract the yellow metal; and this was probably attempted, as it now sometimes is,

* Abstract from "A New Center of Gold Production," by Frank Karuth, F.R.G.S. London, 1894.

by pulverizing the quartz by hand, and then washing in the same way as sand or gravel. The only improvement on this rude process was the introduction by the Spaniards, in some districts, of the Mexican "arrastra," which is a form of stone mill moved by buffalo power—one or two circular stones are made to perpendicularly traverse circularly a large flat rock laid horizontally, whereby about 250 pounds of coarse quartz is reduced to minute fragments. Of course the float gold and auriferous pyrites are thus lost; but it is doubtful, even at this day, whether the natives are aware of the auriferous character of the pyrites that almost always accompany auriferous quartz, sometimes in considerable quantities. Mr. Hilton, a mining engineer who visited Luzon in 1890-91, relates how he was invited to view a vein of gold quartz, and found the shaft full of water, and no means of draining except "by a posse of seventeen natives, who, forming a chain, handed palm-leaf buckets from water level to surface. Nothing was known of amalgamation processes, but the crushed material was washed in wooden bowls, of which it required at least 400 to deal with a ton."

Mr. Simpson, too, a veteran Ballarat gold-mining captain, as the result of a visit to Luzon in 1892, corroborates Mr. Hilton, observing: "The native miners' mode of operations was based on sound engineering principles, in so far as draining is concerned, as is shown by their putting in the (to them) very costly adit from the creek at the foot of the hills on which the mines visited are situated. They baled the water out into small buckets, holding from 2 to 2½ gallons each, and by literally filling the various shafts with men, who passed the buckets from one to another, they managed without the use of any explosive to realize some thousands of ounces of gold."

Though native miners prefer to work where baling is not necessary, such opportunities are not frequent. In one instance they removed an entire hillock down to the sea level, and must have handled immense quantities of paying quartz, for they remove nothing that does not pay. This hillock must have been at least 400 feet high and correspondingly broad. At Mambulao ("Place of Gold") the Spaniards formerly had important workings, and a vast adit opening near the sea, in solid masonry, has stood the neglect of decades, and may probably be made useful again. Record has it that the weekly sales of this mine, when in a flourishing condition, amounted to over 1,000 ounces, all produced in the primitive way, by washing the pounded quartz.

The reason why so little is known of Philippine gold is, there has never been any official control of the output, or any form of tax thereon. The miners live in isolated districts and villages, having little communication with the outside world, and that little through that omnipresent man of business, John Chinaman, who penetrates the most distant settlements, buys the gold with his wares, and sends it out of the country; and he affords no information as to the volume of his trade. "Paracale" gold is well known in Manila, but few Manilese know where Paracale is, and fewer have ever visited it; yet it is a prosperous village, with a good deal of trade and a large native mining population. The "Paracale" gold dust is milled into tiny ingots, a small bivalve serving as a mould, so that the mass shows the shape of the shell; and the traces of the probing auger of the Chinese purchaser are always in evidence.

Copper.—This metal is found in many parts of the archipelago, and cupreous pyrites are not infrequently met with accompanying quartz veins, but in such small quantities as to exclude all commercial value. In the central mountain ranges of Luzon, however, between Cagayan and Ilocos, considerable deposits of ore are distributed that were worked by the Igorroté tribe long before the advent of the white race. They employed fire and water to soften and disintegrate the rocks, exactly as the "mound builders" or their contemporaries are supposed to have done to secure the ores in the Lake Superior district of Michigan; and while the natives made the enterprise profitable, an elaborate plant and all the skill of Spanish metallurgists proved futile, though at the time the ore was worth nearly $500 per ton.

A very peculiar deposit of native copper occurs on the east coast of Luzon, the metal being found in a bed of gravel in little globular or pear-shaped nuggets, that assay over 90 per cent., and with a not inconsiderable admixture of silver and gold. The extent of this deposit and its commercial value have not been determined as yet, and its origin is rather puzzling.

Galena, both auriferous and argentiferous, is found in veins in Luzon and Cebu, sometimes accompanied by zinc blends; also "massicot" (plumbic monoxide) is had, which, when heated to 600° F., metamorphoses into "red lead."

Coal.—The only coal deposits which have been to any degree developed are in and extend over the greater part of the island of Cebu. It may here be remarked that none of the Philippine deposits yield true coal, but lignite instead, though they afford an excellent substitute for the former. On the island of Mashbate is a supply that has been drawn upon to some extent by local steamship owners, and it is estimated will yet yield above 600,000 tons. The best Cebu lignite is very little inferior to Australian and English coal as fuel. It is very black, and closely resembles cannel coal, and, by Spanish authors, is described as a "pitchy lignite" (lignita piciformes).

Precious Stones.—Small rubies and hyacinths have been observed in roughly washed alluvial gold brought from the mountains, and there are reasons for believing larger stones may be had; also, though no systematic search for banks of pearl shells has ever been undertaken, the close proximity of the Sulu Archipelago, coupled with the fact that pearls of a very fine quality, but of unknown origin, are often marketed in Manila, afford reasonable grounds for the surmise that the Philippines may yet become the great pearl mart of the world.

All known gases have now been condensed into liquids which can be manipulated at their boiling-points under atmospheric pressure in suitably arranged vacuum vessels. With hydrogen as a cooling agent, it will be possible to get within 20° or 30° of the zero of absolute temperature, and its use will open up an entirely new field of scientific inquiry.—Chemical News (London).

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